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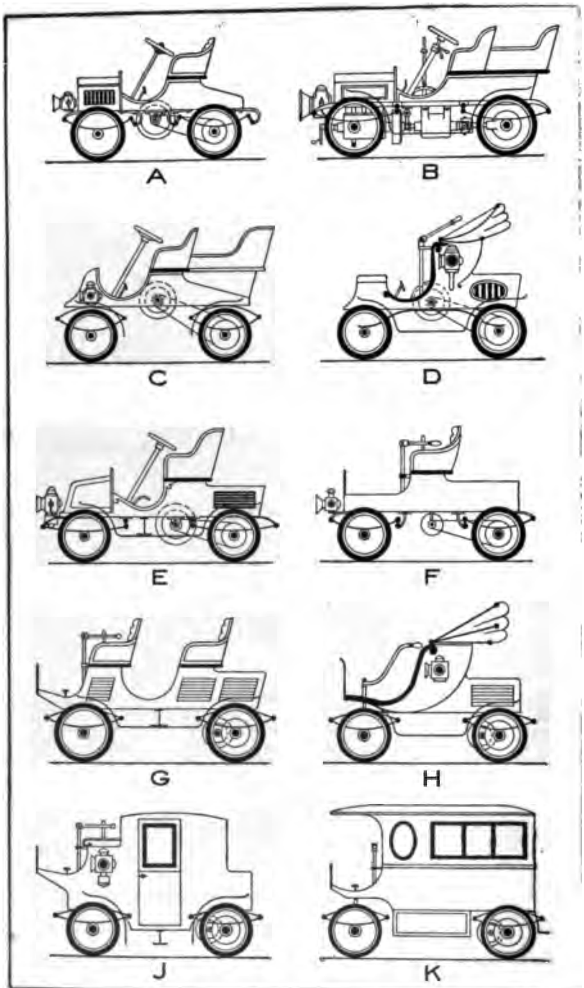

Typical American Gasoline and Electric Automobiles.
See Automobiles, Typical American.

1903

The Automobile HAND-BOOK

A WORK OF PRACTICAL INFORMATION FOR THE USE OF

Owners Operators *and* Automobile Mechanics

including

ROAD TROUBLES
MOTOR TROUBLES
CARBURETER TROUBLES
IGNITION TROUBLES
CLUTCH TROUBLES
STARTING TROUBLES

By L. ELLIOTT BROOKES

Giving full and concise information on all questions relating to the *construction, care and operation* of gasoline and electric automobiles. With numerous tables, useful rules and formulas, and over one hundred illustrations.

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The Automobile Hand-book

Accumulators—See Storage Batteries.

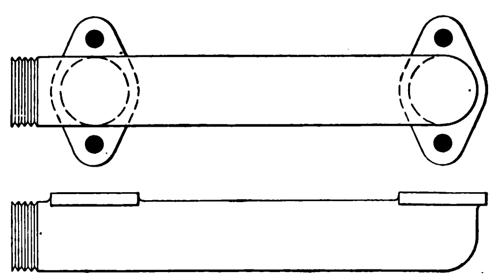
Acetylene. A number of inconveniences are attached to the use of acetylene. The problem of properly purifying it has yet to be solved. Metallic compounds of sulphur, phosphorus and nitrogen and free carbon are contained in the carbide, and the gas has in it many impurities which endanger health when burned in closed rooms. The free carbon in the carbide gets into the burners in the form of fine dust and obstructs them. A great annoyance is smoking of the lamps, which takes place after two or three hours burning. This is due to decomposition of the acetylene by the heated burner, by which carbon is deposited in the narrow opening. Many of the so-called spontaneous explosions of this gas have without doubt been caused by high temperature in the generator—see also Gas Lamps.

Acid Solutions. The electrolyte, or solution used in storage battery cells, is made by pouring sulphuric acid into distilled water until the specific gravity becomes 1.12. The solution becomes extremely warm and should not be used until its temperature is about 60 degrees,

A good soldering solution is made by neutralizing hydrochloric acid with zinc until it is no longer strongly acid.

Admission-pipes, Diameter of. The internal diameter of the admission or inlet-pipe leading from the carbureter to the admission-valve chamber should not exceed one-fourth the diameter of the motor cylinder.

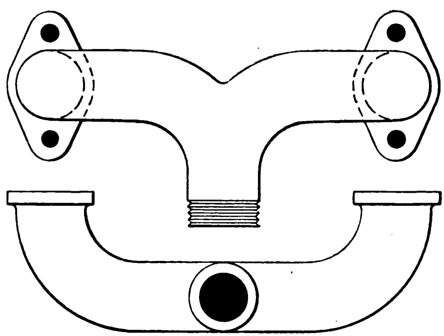
This limitation is necessary in order to produce as great a partial vacuum as is possible in the admission-pipe. The carbureter should be placed as close as possible to the admission-valve chamber of the motor in order to secure the best



ADMISSION PIPE FIG. 1

results. Short turns or bends in the admission-pipe greatly increase the air-friction in the pipe and at high speeds greatly diminish the volume of the charge drawn into the cylinder by the inductive or suction action of the motor-piston.

An admission-pipe with a side inlet and short bends, for a two-cylinder motor, is shown in Figure 1. Such forms of construction should be avoided whenever possible. Figure 2 shows an admission-pipe of approved design, with long



ADMISSION PIPE FIG. 2

bends, for a two-cylinder motor. The radius of curvature of the pipe on its center line should not be less than twice the outside diameter of the pipe. If space allows, a radius of three times the outside diameter of the pipe will give better results than two diameters.

Admission-port—See Motor, Two-cycle.

Admission-valves, Diameter and Lift of. For a motor of any desired bore and stroke and speed in revolutions per minute, the following formula may be used to determine the diameter of the valve opening:

Let B be the bore of the motor cylinder in inches, and S the stroke of the piston also in inches. As R is the number of revolutions per minute and D the required diameter of the valve opening, then

$$D = \frac{B \times S \times R}{15{,}000}$$

Example: Required the diameter of the admission-valve opening for a motor of 4½-inch bore and stroke at 1,000 revolutions per minute.

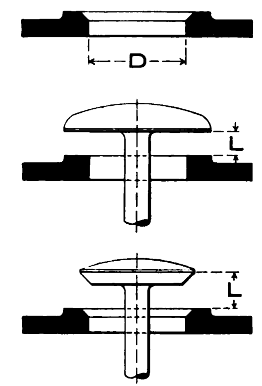
Answer: As 4½ multiplied by 4½ and by 1,000 equals 20,250, then 20,250 divided by 15,000 gives 1.35 inches as the diameter of the valve opening.

In practice, a motor of 4½ inches bore and stroke has with a mechanically operated admission-valve an opening of 1½ inches diameter and runs up to 1,200 revolutions per minute.

The upper view in Figure 3 shows clearly the diameter D referred to in the formula, as some persons are in the habit of referring to the outside diameter of the valve itself instead of the opening in the admission-valve seat. The center view in Figure 3 shows an admission-valve with a flat seat, which is known as a mushroom valve, on account of its shape. For this form of valve to give a full opening the lift should be exactly

one-fourth of the diameter of the valve opening: therefore if L be the required lift of the valve, and D the diameter of the valve opening, then

$$L=\frac{D}{4}=0.25\ D$$



VALVES FIG. 3

The lower view in Figure 3 shows a valve with a bevel seat, having an angle of 45 degrees, which is most commonly used. The lift of this form of valve requires to be about three-eighths of the diameter of the valve opening: that is, if L is the required lift of the valve and D the diameter of the valve opening, then

$$L=\frac{D}{2.83}=0.35\ D$$

The bevel-seat form of valve is to be preferred to the flat-seat or mushroom type of valve, for two reasons: first, that it is more readily kept in shape by regrinding, and second, it gives a freer and more direct passage for the gases, as will be plainly seen by reference to the lower view in Figure 3.

Table No. 1 gives the correct diameter of valve openings for motors from 3 by 3 to 6 by 6 inches bore and stroke, with speeds from 900 to 1,800 revolutions per minute, and piston velocities of 600, 750 and 900 feet per minute, for mechanically operated admission-valves.

TABLE NO. 1.

DIAMETER OF MECHANICALLY OPERATED ADMISSION-VALVES.

Bore of Cylinder.	Stroke of Piston	Piston Speed in Feet per Minute.					
		600		750		900	
		Revs. per Minute.	Dia. of Valve Opening.	Revs. per Minute.	Dia. of Valve Opening.	Revs. per Minute.	Dia. of Valve Opening.
3	3	1200	0.72	1500	0.90	1800	1.08
3½	3½	1030	0.84	1285	1.05	1570	1.26
4	4	900	0.96	1125	1.20	1350	1.44
4½	4½	800	1.08	1000	1.35	1200	1.62
5	5	720	1.20	900	1.50	1080	1.80
5½	5½	655	1.32	820	1.65	965	1.95
6	6	600	1.44	750	1.80	900	2.16

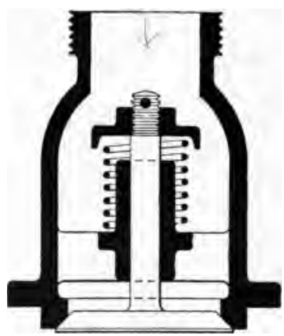
Atmospheric or suction operated admission-valves require to be of somewhat larger diameter than mechanically operated admission-valves, for two reasons: first, that the incoming charge has to lift the valve from its seat and keep it suspended during the suction stroke of the motor piston, and secondly on account of the resistance offered by the valve spring, which tends at all

times to keep the valve on its seat. For an atmospherically operated admission-valve which will insure practically a full charge in the motor cylinder the formula should be

$$D = \frac{B \times S \times R}{12,750}$$

The proper diameter for atmospherically operated admission-valve openings may be readily found by increasing the required diameter given in the above table for mechanically operated admission-valves, by 15 per cent.

FIG. 4



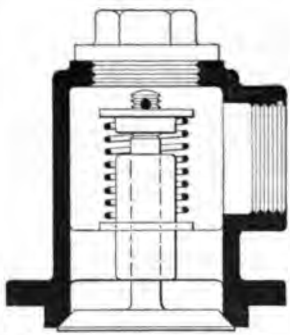
ADMISSION VALVE

Example: What should be the correct diameter for the atmospherically operated admission-valve of a motor of $4\frac{1}{2}$ inches bore and stroke, with a piston velocity of 750 feet per minute?

Answer: Under the column headed 750 and opposite $4\frac{1}{2}$ by $4\frac{1}{2}$, the diameter given is 1.35. Then 15 per cent of 1.35 equals 0.20, which, added to 1.35, gives 1.55 inches as the correct diameter for the valve opening under the conditions given—see also Valves.

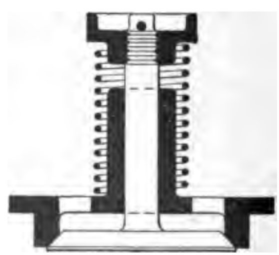
Admission-valves, Forms of. Figures 4 and 5 are two forms of combined admission-valve and valve cage or chamber. Figure 4 has the inlet on top and Figure 5 on the side. Figures 6 and 7 show two forms of detachable or removable admission-valves. The one shown in Figure 7 may be removed from the motor without disconnecting the admission-pipe, as it screws into the combustion chamber and has openings around the lower portion for the admission of the explosive charge to the valve.

Fig. 5



ADMISSION VALVE

Fig. 6



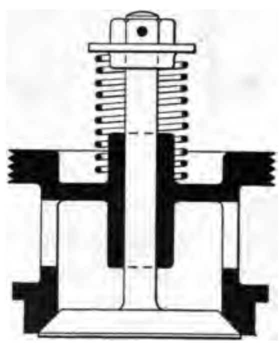
ADMISSION VALVE

Air. Air consists, by weight, of oxygen 77 parts and nitrogen 23 parts; by volume, of 21 parts oxygen and 79 parts nitrogen. One pound of air occupies 13.8 cubic feet of space. One cubic foot of air weighs 1¼ ounces.

Air-cooled Motors—See Gasoline Motor Construction.

Air, Properties of Compressed. The accompanying table, which may be of use to designers or builders of gas or gasoline motors, gives the Mean pressure, Temperature in degrees Fahrenheit, Gauge pressure, Absolute pressure and the Isothermal or heat-pressure of air under compression of from 1 to 6.10 atmospheres.

FIG. 7



ADMISSION VALVE

As energy in the form of power must be used to compress air to any desired pressure, so is energy in the form of latent or stored heat given up by the air during the operation of compression. This heat consequently increases the pressure resulting from the compression, but not directly in proportion to the degree of compression in atmospheres.

This increase of pressure above the Adiabatic or calculated pressure is known as the Isothermal or heat-pressure. As the values of this pressure cannot be calculated by the use of ordinary mathematics, but involve the use of logarithms,

Table No. 2 gives these values for each degree of compression given.

Table No. 2.

Properties of Compressed Air.

Comp. in Atmospheres.	*Mean Pressure.	Temp. in Degrees Fah.	*Gauge Pressure.	*Absolute Pressure.	*Isothermal Pressure.
1	0	60	0	14.7	
1.68	7.62	145	10	24.7	30.39
2.02	10.33	178	15	29.7	39.34
2.36	12.62	207	20	34.7	48.91
2.70	14.59	234	25	39.7	59.05
3.04	16.34	252	30	44.7	69.72
3.38	17.92	281	35	49.7	80.87
3.72	19.32	302	40	54.7	92.49
4.06	20.57	324	45	59.7	104.53
4.40	21.69	339	50	64.7	116.99
4.74	22.76	357	55	69.7	129.84
5.08	23.78	375	60	74.7	143.05
5.42	24.75	389	65	79.7	156.64
5.76	25.67	405	70	84.7	170.58
6.10	26.55	420	75	89.7	184.83

*In pounds per square inch.

Many persons who are not familiar with the properties of gases, estimate the pressure resulting from the compression to a given number of atmospheres, as the number of atmospheres multiplied by the atmospheric pressure, which at sea level is taken as 14.7 pounds per square inch.

This assumption is erroneous and will often lead to grievous mistakes in motor design, generally giving too much compression, which results in premature ignition, commonly known

as backfiring. Such methods of calculation would be true if the air, after compression, was stored in a reservoir and allowed to cool, but under no other conditions.

As the Isothermal pressures given in the table are in absolute terms, to reduce them to gauge pressure terms, 14.7 pounds must be deducted to give the corresponding gauge pressure.

Air Resistance, Horsepower Required to Overcome. The power required to move a plane surface, such as the vertical projection of an automobile, against the air, does not become of much importance until the car attains a speed of 10 to 12 miles per hour, when it becomes an important factor.

The horsepower required to propel an automobile against the resistance of the air may be approximately calculated by the following formula. Let V be the velocity of the car in feet per second, and A the projected area of the front of the car in square feet—this may be assumed as the height from the frame to the top of the body multiplied by the width of the seat at the floor line of the car—let H.P. be the horsepower required to overcome the air resistance, then

$$\text{H.P.} = \frac{V^3 \times A}{240,000}$$

To simplify the use of the above formula, Table No. 3 gives speeds in miles per hour cor-

responding to their respective velocities in feet per second and also cubes of velocities in feet per second.

Table No. 3.

Cubes of Velocities in Feet per Second.

Miles per Hour of Car.	Feet per Second.	Cube of Velocity in Feet per Second.	Miles per Hour of Car.	Feet per Second.	Cube of Velocity in Feet per Second.
10.2	15	3,375	34.0	50	125,000
13.6	20	8,000	40.9	60	216,000
17.2	25	15,625	47.7	70	343,000
20.4	30	27,000	54.4	80	512,000
27.2	40	64,000	61.3	90	729,000

To ascertain approximately the horsepower that will be necessary to drive a car against a wind of known velocity, the speed of the car must be added to that of the wind, and the required horsepower may be found either by use of the formula given or by reference to Table No. 4 which gives the horsepower per square foot of projected surface required to propel a car against the resistance of the air, with varying speeds in miles per hour or velocities in feet per minute.

The horsepower given by the formula and Table No. 4 simply refers to the **additional power** necessary to **overcome air resistance** and not to the **actual power** required to propel a car at a given speed; this is entirely another **matter.**

TABLE NO. 4.

HORSEPOWER REQUIRED PER SQUARE FOOT OF SURFACE, TO MOVE A CAR AGAINST AIR RESISTANCE.

Miles per Hour of Car.	Feet per Second.	Horse-power per Square Foot of Surface.	Miles per Hour of Car.	Feet per Second.	Horse-power per Square Foot of Surface.
10	14.7	0.013	40	58.7	0.84
15	22.0	0.44	50	73.3	1.64
20	24.6	0.105	60	87.9	2.83
25	36.7	0.205	80	117.3	6.72
30	44.0	0.354	100	146.6	13.12

Air Tubes- -See Tires.

Alcohol, Properties of. A carbureter designed to operate with alcohol can always be used with gasoline, but the reverse conditions are not true, that is, a gasoline carbureter will not operate successfully with alcohol, except in some rare instances. Alcohol evaporates slower than gasoline and its time of combustion is much slower, but it maintains its mean effective explosion pressure far better than gasoline.

Explosive motors fitted with alcohol carbureters make far less noise than when using gasoline as a fuel, due to the slower burning of the explosive charge, they also make less smoke and smell.

The jet or spray of a float-feed carbureter will have to pass nearly 40 per cent more liquid fuel than when using gasoline, consequently the opening in the nozzle must be proportionally larger.

A carbureter using alcohol must be fitted with some form of device to heat the alcohol to ensure rapid evaporation—this is usually done

by surrounding the mixing-chamber with an exhaust-heated jacket.

The same quantity of alcohol will only take a car two-thirds of the distance that gasoline will, hence greater storage capacity would be needed on a car using alcohol as a fuel.

An explosive motor designed to use alcohol requires a greater degree of compression than a motor of the same bore and stroke designed to use gasoline, in order to develop the same power.

Alloys, Composition of. The proper composition of alloys of metals for the bearings and other parts of an automobile is a very important consideration from a constructive standpoint. Table No. 5 gives the composition of various alloys of metals and also solders for different uses.

TABLE NO. 5.

COMPOSITION OF ALLOYS.

	Tin.	Copper.	Zinc.	Antimony.	Lead.	Bismuth.
Bronze, for Motor bearings...	13	110	1	...	...	...
Bronze, for Axle bearings....	25	160	5	...	...	...
Brass, for light work, other than bearings..............	...	2	1	...	...	...
Bronze flanges, to stand brazing....................	...	32	1	...	1	...
Genuine Babbitt metal......	10	1	...	1	...	...
Bronze, for bushings.........	16	130	1	...	...	...
Metal to expand in cooling, for patterns	...	...	...	2	9	1
Genuine bronze.............	2	90	5	...	2	...
Solder, for tin...............	1	...	...	...	2	...
Spelter, hard...............	...	1	1	...	...	...
Spelter, soft	1	4	3	...	...	...

Alternating Current, Use of. It is not only useless but absolutely injurious to attempt to charge a storage battery directly from an alternating current circuit. This can only be done by means of a rotary converter, which is in reality a motor-generator, receiving its power from the alternating current and transforming it into a direct current which can be used to charge the batteries.

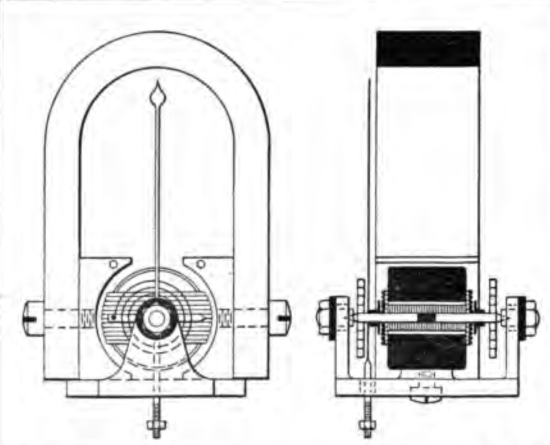
Aluminoid, Composition and Use of. Aluminoid is composed by weight of 60 parts aluminum, 30 parts tin and 10 parts zinc. It has a tensile strength of about 18,000 pounds and is a very suitable material for crank chambers, gear cases and small brackets, being light, extremely ductile and readily machined.

Aluminum Solder. The following formula is for a solder which will work equally well with aluminum or aluminoid: Tin, 10 parts—cadmium, 10 parts—zinc, 10 parts—lead, 1 part. The pieces to be soldered must be thoroughly cleansed and then put in a bath of a strong solution of hyposulphate of soda for about two hours before soldering.

Ammeter, Construction of. Ammeters for automobile use are constructed on the principle of the D'Arsonval galvanometer with a permanent magnetic field. The special feature is a small oscillating coil mounted on cone-point bearings surrounding a stationary armature which is

centrally located between the pole-pieces of a permanent magnet, with a pointer or index-finger which indicates the electrical variations on a graduated scale.

The construction of an ammeter is fully shown in the two views in Figure 8. The permanent magnets used in its construction are of a special



AMMETER FIG. 8

quality of hardened steel, made only for this purpose and possessed of great magnetic permeability. The pole-pieces, which are of soft steel and well annealed, are attached to the inside of the lower part of the magnet legs, the joints between the pole-pieces and the magnet legs are usually ground to insure the full efficiency of the magnetic circuit. The soft iron core of the coil

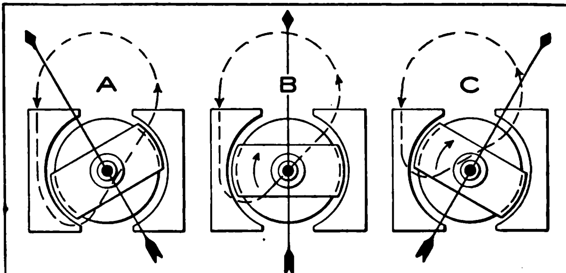
is for the purpose of rendering uniform the magnetic field in which the coil has to oscillate. A coil of insulated wire is wrapped upon the stationary armature at right angles to its axis, that is to say, in the same manner that thread is wound upon a spool, which is short-circuited on itself, that is to say, the ends of the wire forming the coil are fastened together. This coil of wire is for the purpose of choking the magnetism induced in the stationary armature by the oscillating coil, as it generates what are known as eddy currents within itself, thus making the instrument periodic, or dead-beat, in its indications. Around the armature core and outside the short-circuited coil of wire is wound the active or oscillating coil and at right angles to the direction of the winding of the first coil. The oscillating coil consists of a number of turns of fine insulated copper wire, to which the current is conveyed through the medium of the controlling springs at each end of the spindle, which is in two parts and connected together by a suitable sleeve of insulating material, as shown.

The pointer or index-finger is made with a boss or hub to go over the end of the spindle of the active coil and also has an extension with a small counterweight or balance, so that the pointer may be accurately adjusted.

The only difference in the construction of a voltmeter and an ammeter is that in the former

the active or oscillating coil is in series with a high resistance, while in the latter it is connected across the terminals of a shunt-block. The voltmeter is in reality an ammeter, the resistance serving to keep the amperage in step with the voltage.

Reference to the three views, marked respectively A, B and C in Figure 9, will show clearly the principle of the operation of an ammeter or

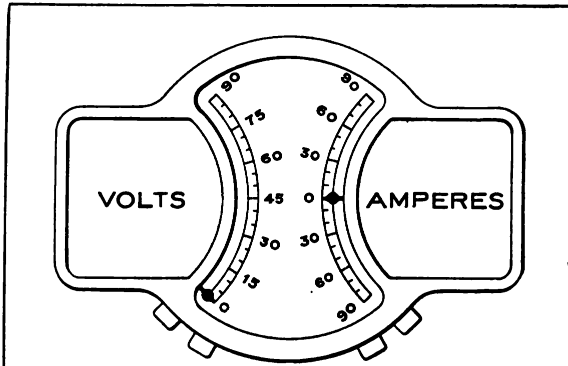


AMMETER DIAGRAM FIG. 9

voltmeter and the reason that they record the current strength or pressure of an electric current accurately.

Ammeters are of two kinds, the double-beat type, as shown in Figure 8, which indicates the current strength or number of amperes flowing in the electric circuit, without any regard to the polarity of the terminals of the circuit, by the pointer or index-finger moving either to the right or to the left of the zero position. The single-

beat type of ammeter only records in one direction, by the pointer moving from the left to the right of the graduated scale of the instrument, consequently the polarity of the terminals of this type of ammeter are marked on its outer casing and the polarity of the terminals of the electric circuit must consequently be determined before connecting them with the ammeter.



VOLT-AMMETER FIG. 10

A volt-ammeter, such as is commonly used on electric automobiles, is shown in Figure 10. This instrument is simply a voltmeter and a double-beat ammeter mounted on a single base and enclosed in a common case, with their graduated scales adjoining each other.

Ampere—See Electrical Rules and Formulas.

Ampere-hour, Definition of. The term ampere-hour is used to denote the capacity of a

storage or a closed-circuit primary battery for current. A storage battery that will keep a 2 ampere lamp burning for 8 hours is said to have a 16 ampere-hour capacity. In a similar manner an 80 ampere-hour battery would operate the same lamp 40 hours. The voltage of a battery does not enter into the calculation of its ampere-hour capacity.

Angle Iron—See Structural Shapes.

Animal Power, Capacity of. A man can exert a pull of 30 pounds, for 10 hours a day, with a speed of 1.70 miles per hour.

A man carrying a load a short distance and returning unloaded, can carry 135 pounds 6 miles in a day. He can also carry 120 pounds 8 miles in a day—or push in a wheelbarrow 150 pounds 10 miles as a day's work.

A man can walk on a smooth, level road for 8½ hours at the rate of 3.67 miles per hour.

A horse can travel 400 yards: at a walk, in 4½ minutes—at a trot, in 2 minutes—at a gallop, in 1 minute.

A work-horse, on a good road, can pull 1,600 pounds 23 miles in a day, weight of vehicle included.

A good horse, in the best of condition, can only exert his full capacity, or one horsepower, for 6 hours per day.

The work of one horse is approximately equal to that of five men.

Anti-freezing Solutions. To prevent the water in the jacket of a gasoline motor from freezing during cold weather, calcium-chloride or glycerine may be used. The calcium-chloride should be dissolved in hot water in the proportion of 4 pounds of calcium-chloride to 1 gallon of water. Allow the solution to stand until fully settled, then carefully draw off the liquid without disturbing the sediment.

Glycerine in the proportion of 2 pints to 3 pints of water may also be used for the same purpose, but is much more expensive than the calcium-chloride.

Neither of these solutions will stand a twenty degree below zero temperature.

Areas and Circumferences of Circles—See Table No. 6.

Armatures, Slotted and Shuttle Types of. An armature is the rotating part of a dynamo or electric motor which generates electricity or develops power.

The armature shown in Figure 11 is known as the Siemen's H or shuttle type and is the simplest form of wire-wound armature known. The current given by this form of armature is of the alternating type and is converted into a direct-current, when desired, by means of a two-part commutator on the armature shaft.

The slotted type of armature shown in Figure 12 has a more intricate system of winding than

TABLE NO. 6.

AREAS AND CIRCUMFERENCES OF CIRCLES FROM 0.05 TO 10.0, ADVANCING BY $\frac{1}{20}$ OF ONE INCH.

Diam.	Area	Circum.	Diam.	Area	Circum.
.05	.0019	.16	2.05	3.30	6.44
.10	.0078	.31	2.10	3.46	6.59
.15	.017	.47	2.15	3.63	6.75
.20	.031	.63	2.20	3.80	6.91
.25	.049	.78	2.25	3.98	7.07
.30	.070	.94	2.30	4.15	7.22
.35	.096	1.09	2.35	4.34	7.38
.40	.12	1.26	2.40	4.52	7.54
.45	.16	1.41	2.45	4.71	7.69
.50	.19	1.57	2.50	4.91	7.85
.55	.24	1.73	2.55	5.11	8.01
.60	.28	1.88	2.60	5.31	8.17
.65	.33	2.04	2.65	5.56	8.32
.70	.38	2.19	2.70	5.72	8.48
.75	.44	2.36	2.75	5.94	8.64
.80	.50	2.51	2.80	6.16	8.79
.85	.57	2.67	2.85	6.38	8.95
.90	.64	2.83	2.90	6.60	9.11
.95	.71	2.98	2.95	6.83	9.27
1.00	.78	3.14	3.00	7.07	9.42
1.05	.86	3.29	3.05	7.31	9.58
1.10	.95	3.46	3.10	7.55	9.74
1.15	1.03	3.61	3.15	7.79	9.89
1.20	1.13	3.77	3.20	8.04	10.05
1.25	1.23	3.93	3.25	8.29	10.21
1.30	1.33	4.08	3.30	8.55	10.37
1.35	1.43	4.24	3.35	8.81	10.52
1.40	1.54	4.39	3.40	9.08	10.68
1.45	1.65	4.56	3.45	9.35	10.84
1.50	1.77	4.71	3.50	9.62	10.99
1.55	1.89	4.87	3.55	9.89	11.15
1.60	2.01	5.03	3.60	10.18	11.31
1.65	2.14	5.18	3.65	10.46	11.47
1.70	2.27	5.34	3.70	10.75	11.62
1.75	2.40	5.49	3.75	11.04	11.78
1.80	2.54	5.65	3.80	11.34	11.94
1.85	2.69	5.81	3.85	11.64	12.09
1.90	2.84	5.97	3.90	11.94	12.25
1.95	2.99	6.13	3.95	12.25	12.41
2.00	3.14	6.28	4.00	12.57	12.57

TABLE NO. 6—*Continued.*

Diam.	Area	Circum.	Diam.	Area	Circum.
4.05	12.88	12.72	6.25	30.68	19.63
4.10	13.20	12.88	6.30	31.17	19.79
4.15	13.53	13.04	6.35	31.67	19.95
4.20	13.85	13.19	6.40	32.17	20.11
4.25	14.19	13.35	6.45	32.67	20.26
4.30	14.52	13.51	6.50	33.18	20.42
4.35	14.86	13.66	6.55	33.69	20.58
4.40	15.20	13.82	6.60	34.21	20.73
4.45	15.55	13.98	6.65	34.73	20.89
4.50	15.90	14.14	6.70	35.26	21.05
4.55	16.25	14.29	6.75	35.78	21.20
4.60	16.62	14.45	6.80	36.32	21.36
4.65	16.98	14.61	6.85	36.85	21.52
4.70	17.35	14.76	6.90	37.39	21.68
4.75	17.73	14.92	6.95	37.94	21.83
4.80	18.09	15.08	7.00	38.48	21.99
4.85	18.47	15.24	7.05	39.04	22.15
4.90	18.86	15.39	7.10	39.59	22.30
4.95	19.24	15.55	7.15	40.15	22.46
5.00	19.63	15.71	7.20	40.71	22.62
5.05	20.03	15.86	7.25	41.28	22.78
5.10	20.43	16.02	7.30	41.85	22.93
5.15	20.84	16.18	7.35	42.43	23.09
5.20	21.23	16.34	7.40	43.01	23.25
5.25	21.65	16.49	7.45	43.59	23.40
5.30	22.06	16.65	7.50	44.18	23.56
5.35	22.48	16.81	7.55	44.77	23.72
5.40	22.90	16.96	7.60	45.36	23.88
5.45	23.33	17.12	7.65	45.96	24.03
5.50	23.76	17.28	7.70	46.57	24.19
5.55	24.19	17.44	7.75	47.17	24.35
5.60	24.63	17.59	7.80	47.78	24.50
5.65	25.07	17.75	7.85	48.39	24.66
5.70	25.52	17.91	7.90	49.02	24.82
5.75	25.97	18.06	7.95	49.64	24.97
5.80	26.42	18.22	8.00	50.26	25.13
5.85	26.88	18.38	8.05	50.89	25.29
5.90	27.34	18.54	8.10	51.53	25.43
5.95	27.80	18.69	8.15	52.17	25.60
6.00	28.27	18.85	8.20	52.81	25.76
6.05	28.75	19.01	8.25	53.46	25.92
6.10	29.22	19.16	8.30	54.11	26.07
6.15	29.70	19.32	8.35	54.76	26.23
6.20	30.19	19.48	8.40	55.42	26.39

TABLE No. 6.—*Continued.*

Diam.	Area	Circum.	Diam.	Area	Circum.
8.45	56.08	26.55	9.25	67.20	29.06
8.50	56.74	26.70	9.30	67.93	29.22
8.55	57.41	26.86	9.35	68.66	29.37
8.60	58.09	27.02	9.40	69.39	29.53
8.65	58.76	27.17	9.45	70.14	29.69
8.70	59.45	27.33	9.50	70.88	29.84
8.75	60.13	27.49	9.55	71.63	30.00
8.80	60.82	27.65	9.60	72.38	30.15
8.85	61.51	27.80	9.65	73.14	30.32
8.90	62.21	27.96	9.70	73.89	30.47
8.95	62.91	28.12	9.75	74.66	30.63
9.00	63.62	28.27	9.80	75.43	30.79
9.05	64.33	28.43	9.85	76.20	30.94
9.10	65.04	28.59	9.90	76.98	31.10
9.15	65.76	28.74	9.95	77.76	31.26
9.20	66.48	28.90	10.00	78.56	31.42

To compute the area or circumference of a diameter greater than 10 *and less than* 100:

Take out the area or circumference from table as though the number had one decimal, and move the decimal point two places to the right for the area, and one place for the circumference.

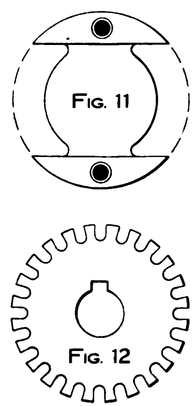
EXAMPLE—Wanted the area and circumference of 56.5. The tabular area for 5.65 is 25.07, and circumference 17.75. Therefore area for 56.5=2507 and circumference=177.5.

To compute the area or circumference of a diameter greater than 100:

Divide by a factor, as 2, 3, 4, 5, etc., if practicable, that will leave a quotient to be found in table, then multiply the tabular area of the quotient by the **square** of the factor, or the tabular circumference by the factor.

EXAMPLE—Wanted the area and circumference of 47.5. Dividing by 5, the quotient is 9.5, for which the area is 70.88, and the circumference 29.84. Therefore area of 70.88×25 = 1772 and circumference= 29.84×5=149.2.

the shuttle type just described. It has, however, a far greater electrical efficiency and gives off a steadier current than the shuttle type. It is the form most generally used for automobile and street railway motors. Like the shuttle type of armature, the current generated by the slotted type of armature is alternating and is converted into a direct-current by means of a commutator of very complicated form—see Electric Motors.



ARMATURES

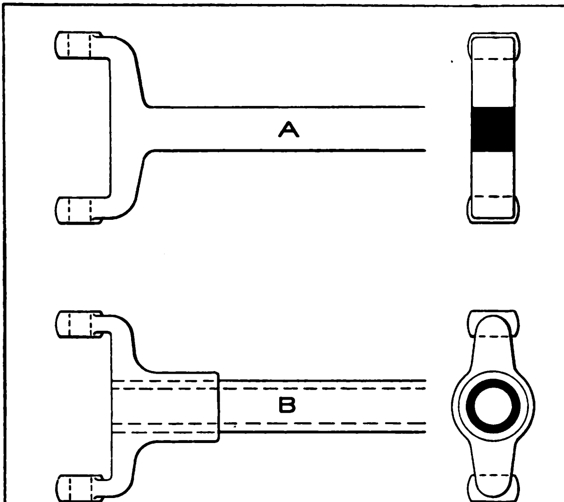
Asbestos—See Insulating Material.

Automobiles, Typical American. Gasoline. A — Runabout. B—Touring car. C—Light car with detachable Tonneau. D—Stanhope. E—Roadster.

Electric. F—Runabout. G—Park trap. H—Phaeton. J—Brougham. K—Depot-bus or light delivery wagon. See first page for drawing.

Axles, Front and Rear. So far it has not been found practical to combine the steering and tractive functions of an automobile in one set of wheels and axle, it is necessary to use a rigid front axle with knuckle-jointed spindles and

utilize the tractive power of the rear wheels only to propel the car. Some of the earlier forms of steering axles had the wheel pivots inclined so as to bring the projection of the pivot axis in line with the point of contact of the wheel with the ground, but as such constructions have not proved

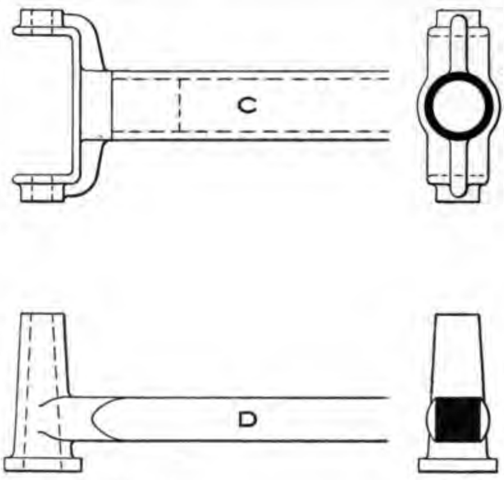


FRONT AXLES FIG. 13

satisfactory they have in most cases been abandoned.

FRONT AXLES. Figures 13 and 14 show four styles of front axles with steering-pivot ends: A shows a solid axle of square section, with the steering-pivot jaws and axle proper, of a single forging—B represents an axle of tubular cross-

section with the steering-pivot jaws bored out to receive the tubular axle which is firmly brazed therein—C shows another style of tubular axle, in which the steering-pivot jaw ends are turned down to fit the inside diameter of the tube and are also brazed in position, while D illustrates a

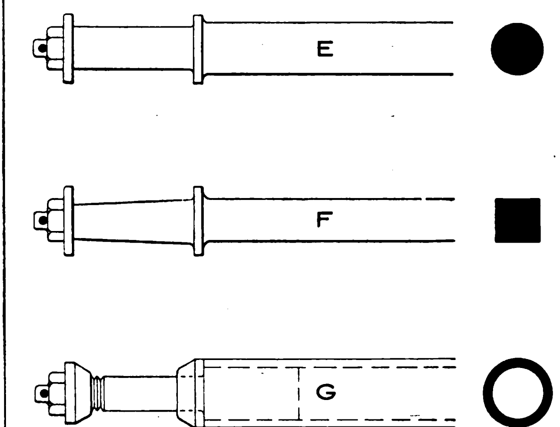


FRONT AXLES FIG. 14

one-piece axle with vertical hubs instead of jaws, which carry L-shaped steering-pivots, instead of the usual form of knuckles.

REAR AXLES. A great many medium and high-powered cars have a double side-chain drive; this necessitates free driving wheels and a rigid rear axle with this form of drive.

Figure 15 illustrates three forms of rigid rear axles for the above described form of drive: E shows a solid axle of circular section with straight spindles for hubs with plain-bearings—F, a solid axle of square section with taper spindles for plain-bearing hubs and G an axle of tubular section with spindles fitted for ball-bearing hubs.



REAR AXLES FIG. 15

Automobiles employing a single chain drive from the motor to the rear axle, generally use either a live solid rear axle with one driving wheel carried upon a loose sleeve attached to one of the gears of the differential, or a rigid tubular axle with a divided live-shaft, to the outer ends of which the driving wheels are keyed. Axles of these types are shown in Figure 16: H illustrates

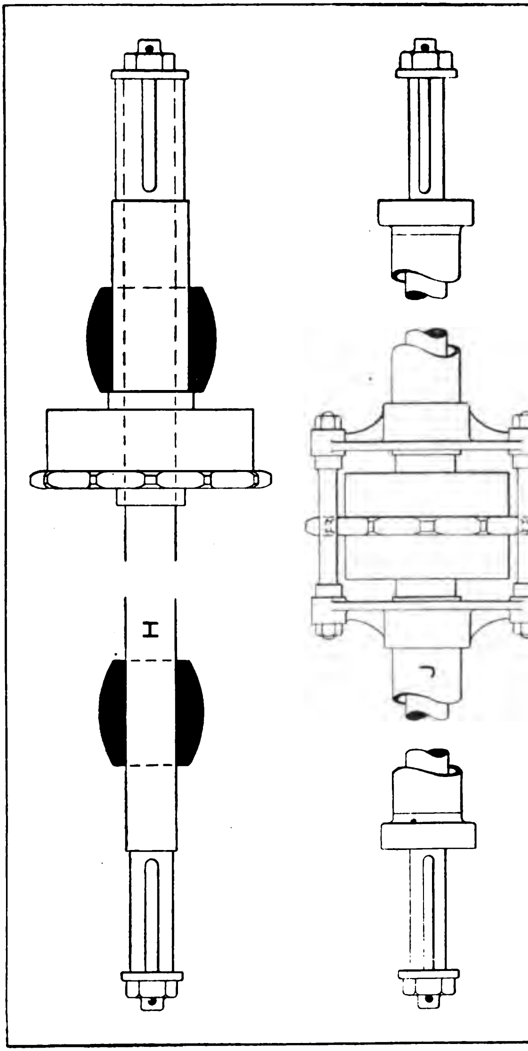


FIG. 16

REAR AXLES

a solid live rear axle with plain-bearings and sprocket on the differential gear case.

Normally both the axle and the sleeve rotate in unionism, but on the car departing from a straight course or turning a corner, the sleeve will move faster or slower than the axle, according to the direction of curvature. A rigid tubular axle with a divided live driving shaft is shown at J; the tubular portions of the axle have spiders on their inner ends, which are connected around the differential gear and sprocket by means of shoulder-studs with nuts, as shown in the drawing. The type of axle illustrated at H may have either plain or roller-bearings, while the type shown at J is usually constructed with four sets of ball-bearings, two sets at the outer ends of the tubular axle and two sets near the center, one on either side of the differential case, within the hubs of the spiders.

In Figure 17, K and L show respectively a live solid rear axle and a rigid tubular axle, equipped with roller-bearings. The spring lugs form part of the roller-bearing boxes of the live axle, while they are usually brazed to the tubular axle near its outer ends.

A rigid tubular axle with ball-bearing live driving shaft is illustrated in Figure 18, the ball-cup or race is adjustable by means of a hexagon upon its outer extension in the rear of the hub of the wheel and is held securely in position and

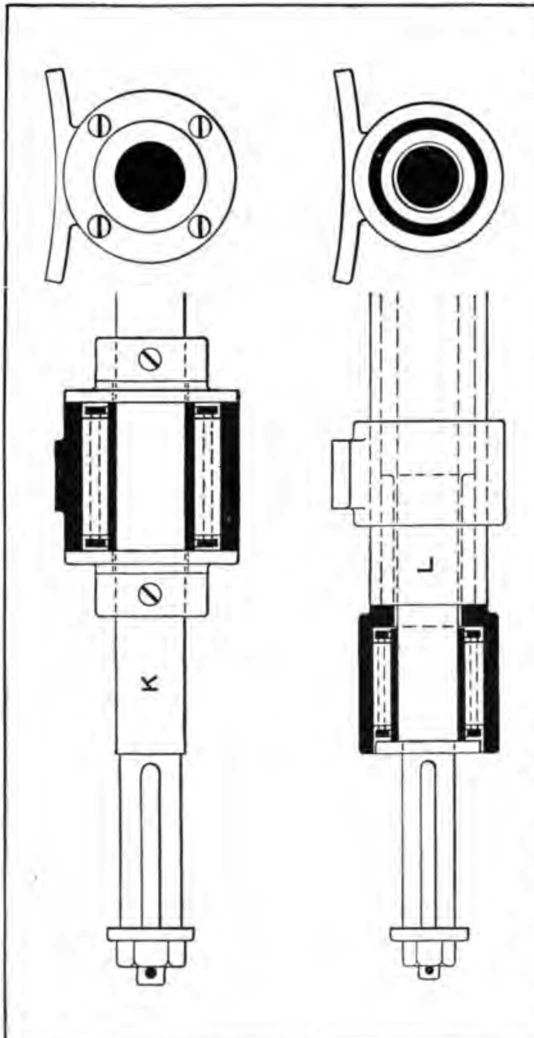
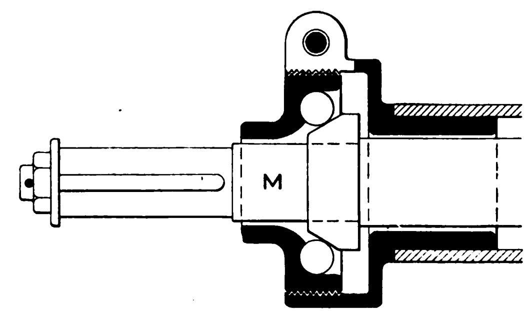


FIG. 17

ROLLER BEARING AXLES

prevented from turning by means of the clamping device shown on the upper portion of the bearing. No separate adjustments for the inner two sets of ball-bearings are necessary, as the teeth of the spur gears of the differential which are keyed to the inner ends of the divided driving shaft, being free to slide upon themselves, allow the shafts M to have a slight longitudinal movement within the axle tube, thus taking up the

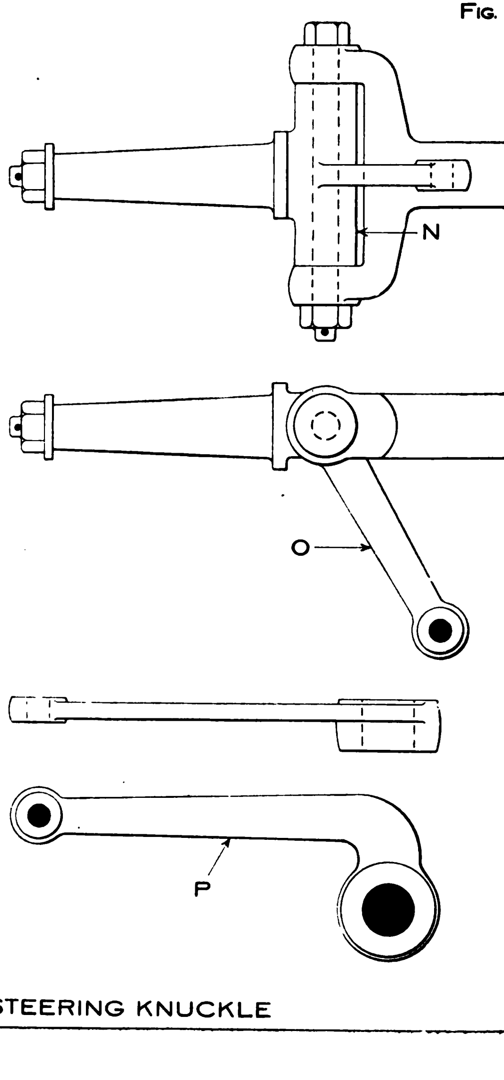


BALL BEARING AXLE FIG. 18

wear of each pair of ball-bearings with a single adjusting mechanism.

STEERING KNUCKLES. In order to obtain ease of operation and secure the shortest turning radius with the least movement of the steering wheel or lever, the knuckle of the steering pivot should be as close to the center of the wheel as is possible. It is also of great importance that

FIG. 19



STEERING KNUCKLE

the steering knuckles should be as heavy as is practically consistent with the size and weight of the car for which they are intended. If this important point be neglected, rapid wear and probable fracture of the knuckles may be looked for.

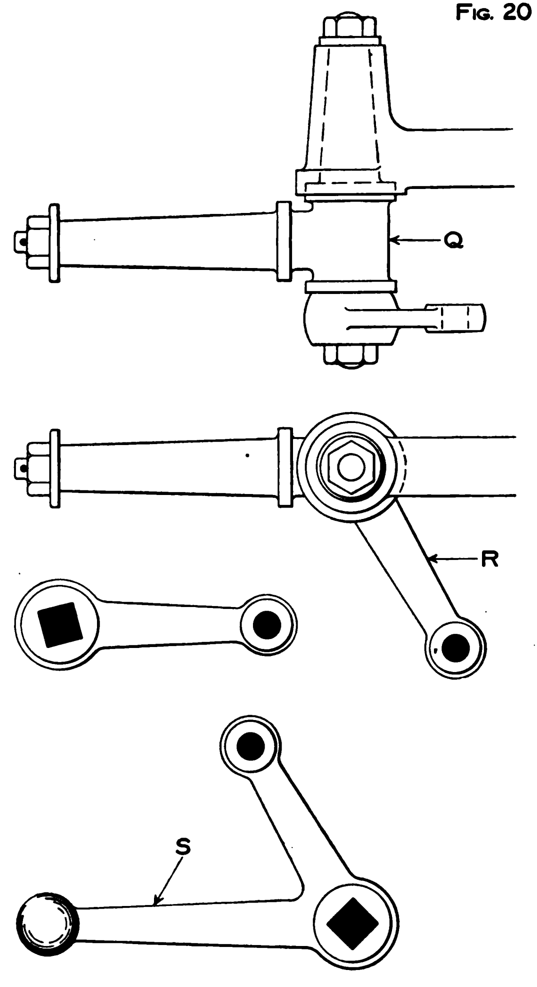
The earliest form of steering knuckle for a pivoted axle was invented by Lankensperger of Munich in 1819, since that time but little change has been made in the basic principle of the pivoted axle.

Steering knuckles at present in use consist of two principal types: a spindle and pivot of T shape and an axle with jaw ends—a spindle and pivot of L shape and an axle with vertical hubs.

A steering knuckle with a spindle and pivot of T shape is shown in Figure 19. The spindle and pivot N and the steering arms O are usually a one-piece forging. The steering arms O are connected by means of a suitable distance rod and the steering lever P is attached to one of the pivots N by turning a shoulder upon it and pinning and brazing the steering lever and pivot hub together.

Figure 20 shows a steering knuckle with spindle and pivot of L shape. The steering arm R goes on the lower end of one pivot Q only, the other pivot having the combined steering arm and lever S on its lower end. The steering arms being detachable, the device may be operated from the

Fig. 20



STEERING KNUCKLE

right or left hand side by simply exchanging the levers R and S. The steering lever S has a ball upon its outer end to fit in the socket on the connecting rod of the steering mechanism.

Backfiring, Causes of. This is a term applied to an explosion or impulse which forces the flywheel of a motor suddenly backwards, that is, in the opposite direction to its proper rotation. The term is sometimes used in connection with explosions which occur in the muffler from the ignition of an accumulation of unburned gases.

CAUSES. An overheated combustion chamber, due to a poor circulation of the cooling water—causing self-ignition of the charge before the proper time.

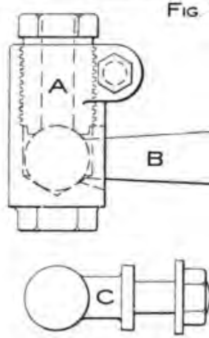
Advancing the ignition point too far ahead when the motor is running slowly under a heavy load—flywheel has not sufficient momentum to force the piston over the dead center, against the pressure of the already ignited and expanding gases.

The presence of a deposit of carbon (soot) or a small projecting surface in the combustion chamber which may become incandescent and cause premature ignition—see also Starting Troubles.

Ball and Socket Joints. To produce a flexible joint capable of operation within certain limitations in any direction, the ball and socket form of joint is generally used on the ends of

the rod which connects the arm of the steering mechanism with the steering lever attached to the hub of one of the steering pivots of the front axle. Figure 21 shows a form of ball-joint used on several makes of cars. The steering lever B has a ball on its outer end, which is held in the socket A by means of a threaded bushing as shown in the drawing. This bushing can be adjusted to take up all lost motion or wear of the working parts and is held from turning by means of the clamping device shown at the upper end of the socket A. The arm of the steering mechanism is provided with a stud C having a ball similar to the one on the end of the steering lever B, which also fits into a socket A. The two sockets are suitably connected by means of a rod.

FIG. 21



BALL JOINT

Ball-bearing Axles—See Axles.

Ball-bearing Hubs—See Hubs.

Band-brakes—See Brakes

Battery Charging Outfit. A four or six volt storage battery used for ignition purposes may be charged very simply in the following manner:

Use ten cells of gravity battery. They are low in first cost and inexpensive to recharge. Sulphate of copper, commonly known as blue stone or blue vitrol and water, is all that is needed to charge the cells, no acids being used. When not in use, put on a closed circuit with a resistance coil of about 150 to 200 ohms, as otherwise a slight local action takes place when the cells are not in use—see Batteries, Dry and Primary, also Storage Battery Charging.

Batteries, Dry and Primary. To ascertain the internal resistance of a dry or primary battery, proceed as follows: With a suitable voltmeter, obtain the voltage of the battery at its terminals when on open circuit. With a known resistance in the battery circuit—say 100 feet of No. 10 B. & S. Gauge copper wire—again obtain the voltage of the battery, also note the amperage with an ammeter; this, however, must be done quickly before polarization occurs.

Let V be the voltage of the battery at its terminals when on open circuit, and v the voltage of the battery with a known resistance in the circuit, let C be the current in amperes flowing through the known resistance and R the required internal resistance of the dry or primary battery, then

$$R = \frac{V - v}{C}$$

To demonstrate the truth of the above formula

and also to prove the correctness of the instruments used in making the test, when the value of the internal resistance R has been ascertained, then C, the current flowing with a known resistance in the battery circuit, should equal in value the result of the formula given below, which is

$$C = \frac{V - v}{R}$$

Dry Batteries. In one respect dry batteries have a decided advantage over storage batteries for ignition purposes, from the fact that on account of their high internal resistance they cannot be so quickly deteriorated by short circuiting.

On account of this high internal resistance, dry batteries will not give so large a volume of current as storage batteries, but a set of dry batteries may be short circuited for five minutes without apparent injury and will recuperate in from twenty to thirty minutes, while a storage battery would in all probability be ruined under the same conditions.

If dry batteries only are used for ignition purposes, two sets should be carried, of not less than 6 cells each, connected with a two-point switch. One set of batteries should be used not to exceed thirty minutes and then the other set switched on. In this manner the batteries will have a much longer life than if used continuously—see Diagram, Wiring for a Single Cylinder Motor.

A dry battery of the usual type consists of a zinc cell which forms the negative element of the battery. The electrolyte is generally a jelly-like compound containing sal-ammoniac, chloride of zinc, etc. The carbon or positive element is enclosed in a sack or bag containing dioxide of manganese and crushed coke, which are the depolarizing agents of the battery.

Dry batteries which have become exhausted may in most cases be recuperated in the following manner: First disconnect the cells from each other and remove their pasteboard covers, then drill a hole in the sealing compound on top of the cell, about one-quarter of an inch in diameter and at least 2 inches in depth so as to insure getting below the sealing compound. Take 1 ounce of bisulphate of mercury and put in a porcelain or earthenware vessel (on no account use a metal vessel) and pour over it one-half pint of boiling water—when cold, draw off the clear solution, being careful not to disturb the yellow precipitate left at the bottom of the vessel, which is useless and should be thrown away at once, as it is a rank poison. Dissolve 4 ounces of sal-ammoniac in 1 pint of hot water and when cold mix with the first solution and the recuperative agent is then ready for use. Take a small glass funnel, or a tin one that is thoroughly painted or enameled, and introduce about a tablespoonful of the liquid into each cell through

the hole already drilled for this purpose. The liquid must be introduced into the cells very slowly, as it will take a long time to absorb, and the cells should be allowed to stand at least 12 hours after filling before being ready for use.

Primary Batteries. When there is no incandescent light circuit at hand or the electric current is of the alternating type, primary batteries of some form or other are very useful to charge small storage batteries which are used for ignition purposes.

The voltage of a set of primary batteries to be used for charging a small storage battery, should exceed the voltage of the storage battery by at least 30 per cent.

Primary batteries of the open-circuit type, such as sal-ammoniac cells, are useless for charging purposes, only batteries of the closed-circuit or constant current type are suitable.

A very simple and inexpensive form of closed-circuit battery for charging purposes is the single liquid type, which uses zinc and carbon electrodes in a 20 per cent solution of sulphuric acid and water, with nitrate of soda as the depolarizing agent.

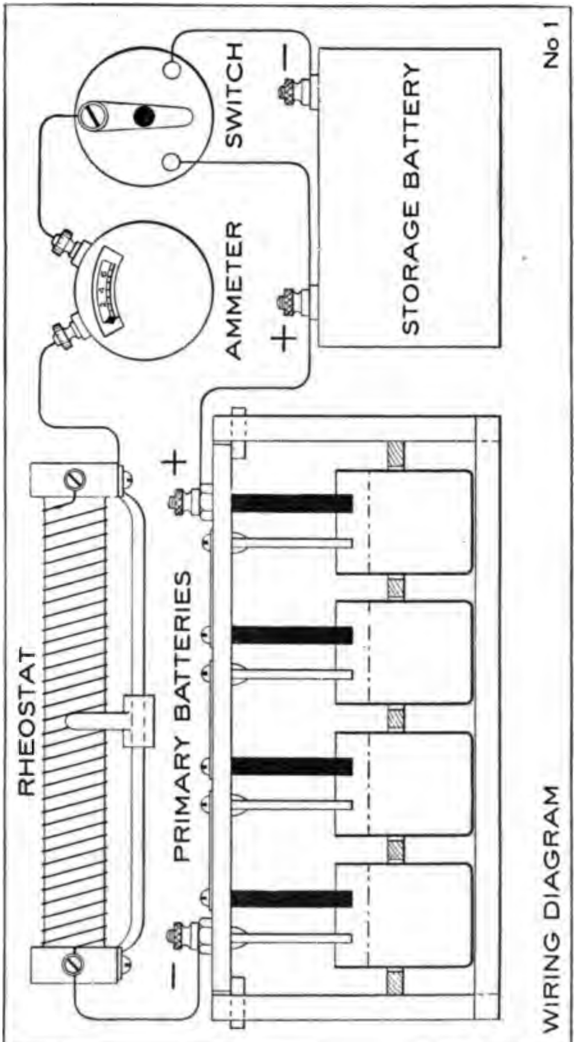
For a 4 volt storage battery four such cells are required, while for a 6 volt storage battery six cells will be necessary for a proper charge.

This form of primary battery has a voltage of 1¾ volts per cell.

The articles necessary for a complete charging outfit are as follows: One small pocket ammeter reading up to 5 amperes, one two-point switch, one resistance coil or rheostat (home made), one set of closed-circuit type of primary batteries and about 25 feet of No. 16 B. & S. Gauge, Okonite or Kerite stranded copper wire for the connections.

The method of connecting the primary batteries, resistance coil (rheostat), ammeter and switch is plainly shown in **Wiring Diagram No. 1.** The positive pole of the primary battery should always be connected with the positive pole of the storage battery, the carbon element is always the positive electrode in both dry and primary forms of batteries. If the polarity of the terminals of the storage battery are not indicated on the case by the + and − signs, which represent positive and negative respectively, their polarity may be readily ascertained by means of a piece of moistened litmus paper (paper soaked in a solution of iodide of starch). Place the piece of moistened litmus paper on a board or other non-conducting material and bring the wires from the storage battery terminals into contact with opposite ends of the paper for a few seconds only—one end of the paper will turn red, this will be next to the wire connected with the negative pole of the storage battery.

The resistance coil or rheostat may be made very simply as follows: Take a piece of hard-


RHEOSTAT
PRIMARY BATTERIES
AMMETER
SWITCH
STORAGE BATTERY
WIRING DIAGRAM
No 1
+
−
+
−

wood 3 inches square and 15 inches long and turn down about 13½ inches of its length to a diameter of 2½ inches in the manner shown. Upon this turned part cut with a round-nose tool a groove or thread one-sixteenth of an inch deep, with 8 threads to the inch. In this groove wind about 50 feet of No. 18 B. W. Gauge bare soft iron wire and connect with a bar and sliding contact as shown in the drawing.

To charge the storage battery, move the sliding-contact to the right until all the resistance is in use, then move the switch-finger to the point on the left and adjust the sliding-contact by moving it to the left until the ammeter shows 3 amperes. Moving the switch-finger to the right will put the battery in the circuit for charging and the sliding-contact should be again adjusted until the ammeter shows 3 amperes. The sliding-contact should be adjusted from time to time to keep the charging current at 3 amperes.

If the storage battery be of 12 ampere-hour capacity it will take 4 hours to properly charge it, if of 18 ampere-hour capacity, 6 hours. The ampere-hour capacity of the battery divided by the amperes of the charging current gives the number of hours required to fully charge the battery when exhausted.

After the storage battery is fully charged the electrodes should be lifted out of the solution as shown in the drawing, by means of the cover to

which they are shown attached, until the battery is again required for use.

Battery Syringe, Use of. Battery syringes are made in two forms. One form of hard rubber with a sliding piston, the other of soft or flexible rubber in the shape of a bulb to be operated by pressure of the hand.

Either form of battery syringe is used to withdraw a portion of the electrolyte or solution from a storage battery cell for the purpose of afterwards testing its density and specific gravity.

Battery Troubles, Causes of. The following are some of the troubles which may occur to a battery:

Loose or corroded terminals will cause a poor electrical contact and failure of the battery to work properly—Remove all thumb-nuts from the binding-posts and clean their contact surfaces thoroughly with emery cloth and screw up firmly after replacing.

Broken wires, or the insulation being worn off some part of the wiring of the car, causing a short-circuit by contact with the metal of the frame—The wires should be disconnected from the battery, and the battery tested across its terminals with an ammeter—If the battery is in good condition, reconnect one wire only to the battery and with an extra piece of wire attached to the other battery terminal, test the coil, commutator and switch connections to locate the

break and around the metal of the frame for the short-circuit; if not found, reverse the wires and proceed as before. In this manner the break or short-circuit must eventually be discovered.

Weak or run-down batteries cause a motor to misfire and run irregularly—A new set of cells should be used to test the motor with; if it still misfires the trouble must be looked for elsewhere.

Dry batteries will show practically their full voltage when almost exhausted—A small pocket ammeter should be used to test each cell with. If any of the cells show less than 5 or 6 amperes they should be at once discarded.

Dry batteries polarize very quickly if left on a closed circuit for a few minutes. This is generally caused by the operator of the car omitting to open the switch, when the motor has stopped for some reason or other—If allowed to rest for 20 to 30 minutes, they will generally recuperate sufficiently to enable the operator to start the motor.

Dry batteries will also polarize from too rapid working or too long use without a rest—Two sets of batteries should always be carried on a car and one set at a time used for about 30 minutes, the other set then being used for another 30 minutes. This method will not only give more satisfactory results than by using a single set, but will prolong the life of the batteries.

A dead or exhausted cell in a set of dry batteries will prevent the rest of the cells from

working properly—With a small pocket ammeter test the amperage of each cell separately until the dead cell is found—Remove the dead cell and substitute a new one in its place if possible, if not, cut the dead cell out of the battery circuit.

The amperage of a dry battery when new is about 12 to 15 amperes on a closed circuit. When an ammeter only shows 5 or 6 amperes, the cell is practically exhausted and should be replaced by a new one.

The voltage of a storage battery should never be allowed to fall below 1.75 volts per cell. This applies to each individual cell and not a set of cells in one case.

When fully charged a storage battery should show 2.2 volts per cell.

A storage battery should never be allowed to remain in a discharged condition over twelve hours.

Never test or experiment with a storage battery by short-circuiting it across its terminals by means of a piece of wire, an old file or a screw-driver.

Troubles with storage batteries, resulting from failure to comply with the above conditions, can only be remedied by the makers.

Bearings, Plain, Ball and Roller. Plain bearings are as a rule in general use for the motors and speed-change gears of gasoline cars, and some makers prefer to use them on the road wheels as well, on account of their simplicity,

ease of renewal when worn and practically inexpensive construction.

Ball-bearings are also used on the armature shafts of electric automobile motors and in the hubs of the front and rear wheels of different makes of cars. Cars equipped with rigid tubular rear axles usually have the live driving shaft fitted with ball-bearings.

Live rear axles are either plain or roller-bearing, as their construction usually renders the use of ball-bearings impracticable.

PLAIN-BEARINGS. For plain-bearings, the shafts of which are continuously running at a high rate of speed, such as motors and speed-change gears, the working pressure per square inch should not exceed **400 pounds.** As the arc of contact or actual bearing surface of a journal-bearing is assumed as one-third of the circumference of the journal itself, the pressure per square inch upon a bearing is therefore equal to the total load upon the bearing, divided by the product of the diameter of the journal into the length of the bearing.

Let D be the diameter of the journal or shaft at its bearing, and L the length of the bearing, if W be the total load or pressure upon the bearing and P the pressure in pounds per square inch of bearing surface, then

$$P = \frac{W}{D \times L}$$

If the total load or pressure on the bearing be known and the diameter of the shaft given, then the proper length of the bearing will be

$$L=\frac{W}{D\times P}$$

If the length of the bearing be known and other conditions as before given, then the proper diameter of the journal will be

$$D=\frac{W}{P\times L}$$

The length of a plain-bearing should not be less than the following proportions:

One and one-third diameters for crank-shaft wrist-pin bearings.

Two diameters for crank-shaft bearings.

Two and one-half diameters for speed-change gears.

Three diameters for live rear axles.

Four diameters for wheel hub bearings.

BALL-BEARINGS. The friction of a well designed ball-bearing varies directly with the load and is entirely independent of the speed. The starting friction of ball-bearings is far less than the best lubricated plain-bearing.

While ball-bearings give less rolling friction than plain-bearings, at their best they still involve a considerable loss of power, due to the fact that they roll in opposite directions and consequently rub against each other, with the result that the

balls soon wear out, in addition to the power losses by friction.

For automobile use the ball-races should have rounded grooves and be also ground perfectly true.

Table No. 7 gives the safe working load for steel balls of varying diameters. It must be considered in this connection that the working load is carried by one ball at a time.

Table No. 7.

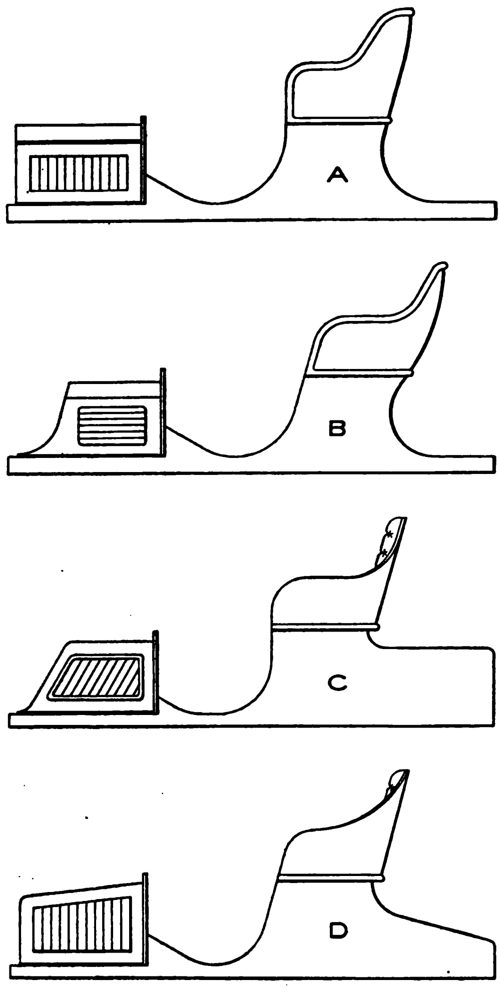
Safe Working Load of Steel Balls.

Diameter of ball.	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$
Working load per ball in pounds.	500	780	1125	1530	2000	2530	3125

Roller-bearings. The amount of power that may be saved by the use of roller-bearings is considerable and the only obstacle to their more general use is the difficulty of obtaining a bearing of simple form which may be easily adjusted in case of wear.

Roller-bearings of parallel form being incapable of adjustment, this objection has been in part overcome by the use of rollers of conical form, which in some cases are designed to also take up the end thrust which occurs in automobile use.

The usual method of mounting rollers for bearings is to enclose them in a suitable form of cage, in which the rollers are separated, so that



BODIES Fig. 22

when rotating on their axes the rollers do not come into contact with each other. In some forms of roller-bearings it is considered good practice to include end thrust ball-bearings at the outer ends of the roller cages, so as to still further reduce the friction incident to the rotation of the roller cages.

Binding Posts—See Terminals.

Bodies, Styles of. The automobile bodies illustrated in Figures 22 and 23 are reproduced from dimensions taken from bodies of cars in actual use and are simply given to show what has been accomplished in the design of automobile bodies at the present state of the industry.

Bodies for cars with vertical motor in front, under a hood or bonnet.

A—For touring car with four-cylinder motor—provision for tonneau in rear.

B—Runabout body for car with two-cylinder motor—space for baggage basket at the rear.

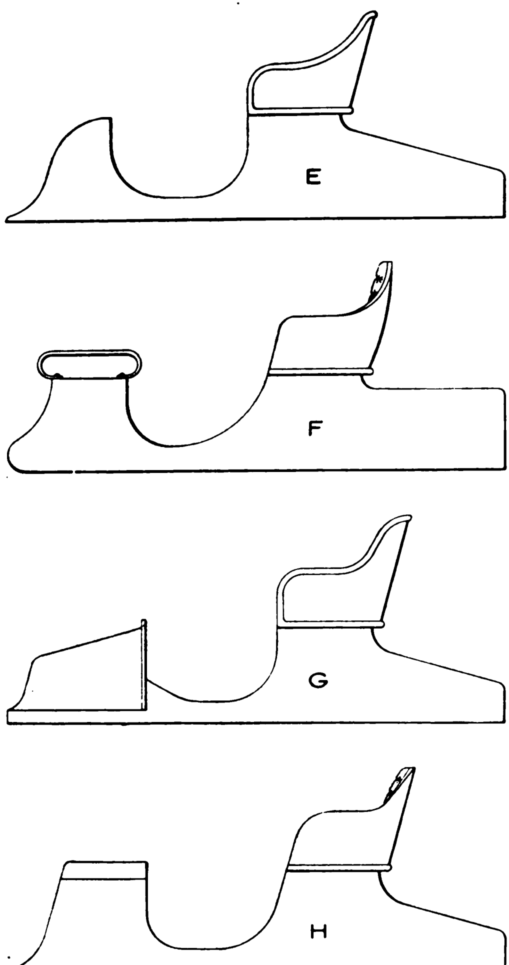
C—Body for light touring car with baggage box in the rear of the body.

D—For light runabout car—space for extra tire and tools in the rear of the body.

Bodies for cars with horizontal motor underneath the body proper.

E—Runabout body with tool and battery box in front—provision for tonneau in rear.

F—Body for electric automobile with extra *front seat*—provision for four trays of batteries,



BODIES Fig. 23

one in front under the extra seat and three trays under the seat and rear extension of the body.

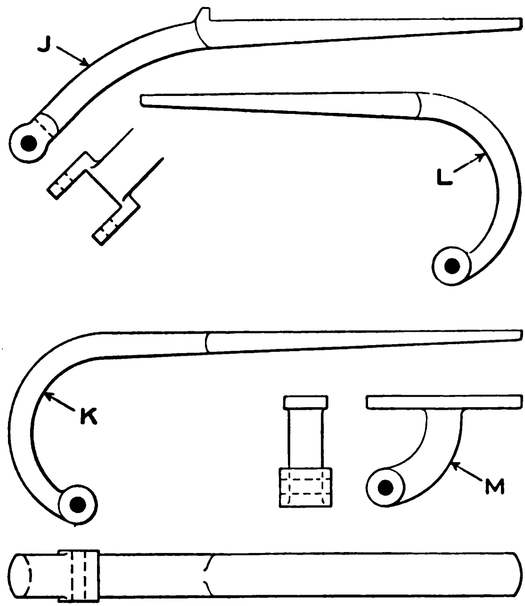
G—Runabout body with imitation hood in front, containing gasoline and water tanks—provision for tonneau in rear.

H—Touring car body with folding front seat, with baggage space—large space for baggage in the rear of the body.

Body-Hangers, Forms of. Since the inception of the automobile, the frame or running gear of the car is in nearly all cases attached to the springs and the body carried upon the frame. The parts or in some cases actually extensions of the frame are or should be properly termed frame-hangers, but they are erroneously and almost universally known as body-hangers, from the term applied to the constructions used in horse-drawn vehicles. Some forms of frame-hangers are of pressed steel construction, but the usual forms are made of drop-forgings. Figure 24 shows some of the forms of drop-forged frame-hangers for automobile use: The front or what is generally known as the pump-handle form of hanger is shown at J, the rear or fish-hook form is shown at K and the forms of hangers used for attaching the inner ends of the springs to the frame are shown at L and M.

Bolts and Nuts, Locking Devices for—See Locking Devices.

Bore and Stroke, Relation of Horsepower to. The horsepower of a gasoline motor when the explosive charge and degree of compression are at their best, depends entirely on the piston



BODY HANGERS FIG. 24

displacement or the volume swept out by the piston and the number of revolutions made by the motor. The term cylinder volume should not be confused with the expression piston displacement, as the former includes the combustion

space, along with the piston displacement. As a matter of fact, the smaller the cylinder volume is in relation to the piston displacement, the greater will be the efficiency of the motor, as the combustion space will be smaller, the degree of compression consequently greater and the residue of burned gases smaller. The only limitation to the degree of compression in the combustion chamber is the danger of premature or spontaneous ignition of the explosive charge.

Brakes, Elementary Forms of. A brake is a mechanism which is a necessary part of the machinery of an automobile and enables the operator by exerting a slight amount of force on a lever to reduce the momentum of the moving car. Brakes used on automobiles may be divided into three classes: Hub or rear wheel brakes, transmission and differential gear brakes. Brakes have also been applied to the tires of the rear wheels, but have proved unsatisfactory and have been abandoned. The forms of brakes in use are single, or double-acting, foot or hand operated, and of the band, block or expanding ring types.

Figure 25, at A, B and C, shows three forms of the simplest type of single-acting band-brake. This type of brake can only be operated successfully with the brake wheel running in one direction only, which is indicated by the arrows in the drawing. If the brakes be operated in the

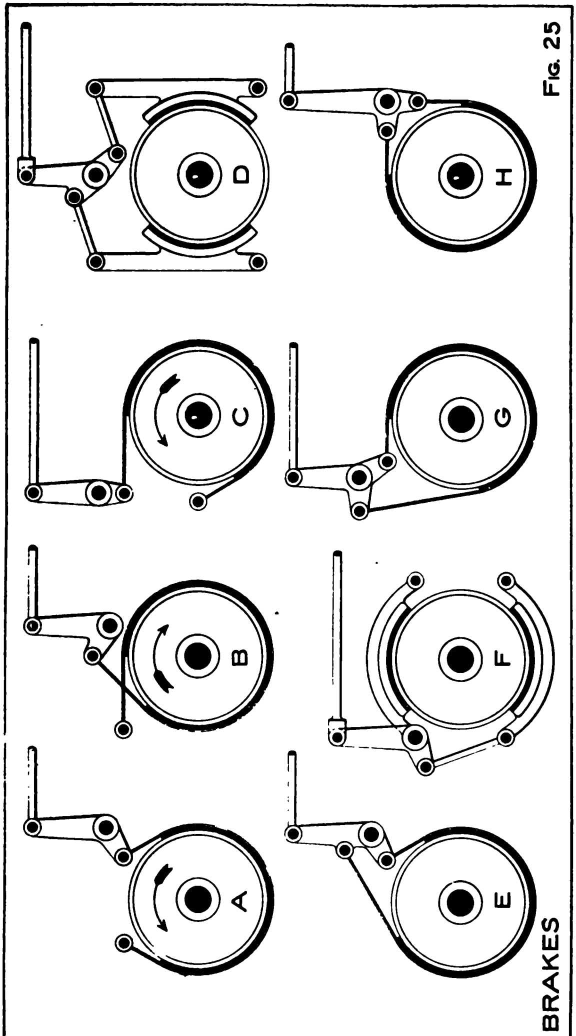


FIG. 25

BRAKES

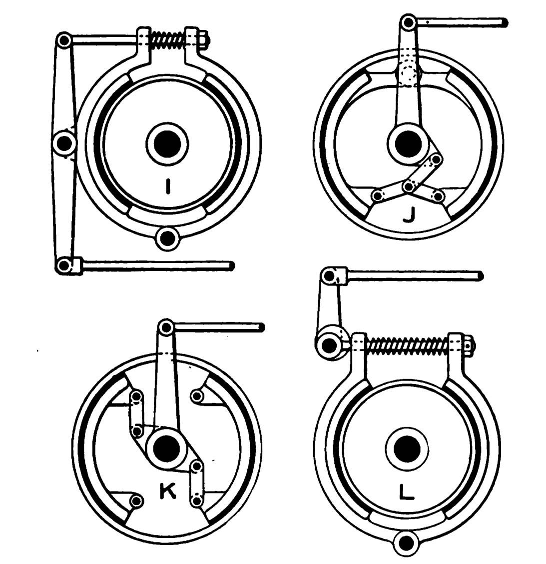
reverse direction to that indicated by the arrows the result will be to jerk the lever or pedal out of the control of the operator of the car.

The three forms of band-brakes shown at A, B and C are all of the same principle, the difference being in the location of the fixed end of the brake-band and the shape of the operating lever. Type D is a form of double acting block-brake. which is designed with a view to eliminate any strain or side thrust upon the shaft of the brake wheel which may be caused by the braking action of the device. Types E, G and H are three types of double acting band-brakes, in which the brake may be applied with the brake wheel running in either direction.

Type F is a form of double acting block-brake, in which the right hand ends of the brake-shoe arms are pivoted to stationary supports, and the left hand ends connected together by means of a link and bell-crank lever as shown in the drawing.

In Figure 26 a form of double acting block-brake I is shown, which is extremely powerful on account of its peculiar construction, in that it has a double leverage upon the brake wheel, which may be readily seen by reference to the drawing. Types J and K are of the form known as internal brakes and of the expanding ring type, the brakes operating upon the inner surface or periphery of the brake wheel, instead of the outside. They are known as hub brakes, being usually

attached to the hubs of the rear wheels of the car. Type L shows a form of block-brake in which the pivoted brake arms are drawn together by the eccentric located on the brake lever shaft. When the lever is released the brake-shoe arms



BRAKES FIG. 26

are forced apart by the action of the coil spring between the upper ends of the arms.

Brake Test with Prony Brake. There is only one way by which the actual horsepower of a gasoline motor may be correctly ascertained and that is by the use of the Prony brake, so called

after its inventor. This simple device gives the actual energy in foot-pounds per minute delivered by the motor at its driving shaft.

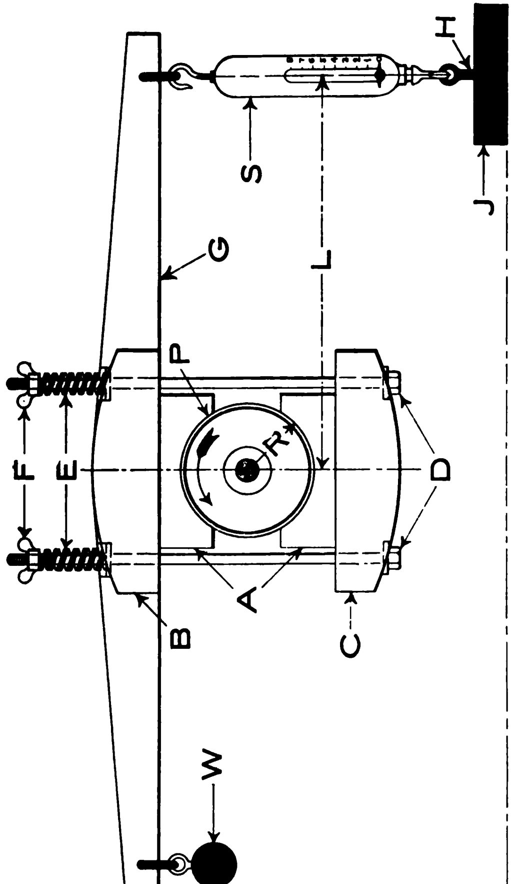
The apparatus for making a brake test is fully illustrated in Figure 27. Two brake-blocks A partially surround the pulley P and are attached to the clamping pieces B and C, which hold the brake-blocks upon the pulley by means of the bolts D, springs E and thumb-nuts F. The lever G is double-ended for the dual purpose of balancing itself and also supplying a place of attachment for the weight W to balance the weight of the spring scale S.

In using this form of Prony brake, the motor is started in the direction indicated by the arrow on the drawing, the brake-blocks A are then tightened by means of the springs E and thumb-nuts F. Then the reading of the spring scale S and the speed of the pulley P are taken.

The motor should be tested at varying speeds and the pull on the spring scale S noted for each.

The actual horsepower can then be calculated for each test and what is known as the **critical speed** of the motor determined, that is the speed at which the motor develops the greatest brake horsepower.

The following formula gives the actual horsepower obtained from the results of a Prony brake test: Let L be the length of the scale lever in inches, and S the pull indicated by the



PRONY BRAKE

FIG. 27

spring scale in pounds. If N be the number of revolutions per minute of the pulley R and B.H.P. the actual or brake horsepower of the motor, then

$$\text{B.H.P.} = \frac{L \times S \times N}{63{,}025}$$

Example: A motor of 5 inches bore and stroke at 600 revolutions per minute gives a pull at the spring scale of 32 pounds, the scale lever is 24 inches long. What is the brake horsepower of the motor?

Answer: Twenty-four inches multiplied by 8 and by 600 equals 460,800—this divided by 63,025 gives 7.30 as the brake horsepower of the motor.

The weight J is shown for use in case the floor of the testing room should be of brick or cement: if of wood the eye-bolt H can be screwed directly into the floor.

Breakdowns. As breakdowns are of frequent occurrence it is of the utmost importance that all the parts of a car that need adjustment or inspection should be readily accessible. Serious breakdowns should never occur on a well kept car.

The usual breakdowns are due to **forgetfulness on the part of the operator** to make some necessary adjustment on the car, or the **lack of tools or extra parts** required to repair a break. On a well kept car troubles as a rule only occur one at a time and those generally at long intervals.

A little **logical thinking** and a few minutes spent in testing usually locates a trouble so that when it is removed a start may be made without further hunting.

The owner of a car should once in a while undertake the task of cleaning the car and making the necessary adjustments therein.

The mechanic may then, under the instruction of the owner, locate a trouble and remove it in a very short time. A bad breakdown may be described as one which will take over half a day to repair. Many an apparently serious breakdown occurs simply from the fact that the **operator fails to examine** the condition of the batteries or the state of the spark plugs or commutator before starting on a trip. These details, being very simple and requiring only a few minutes' work, **should never be neglected.** Before starting on a long trip, to insure getting to the end of the journey without delays, the car should be **thoroughly overhauled** and anything that might give trouble carefully inspected.

Breakdowns, Causes of. Any one of the following troubles may be the cause of a motor stopping or not working properly:

Soot or grease on the spark plug.

Defective insulation of the spark plug.

Points of the spark plug too far apart.

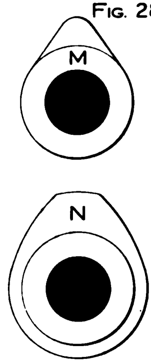
Contacts of the coil vibrator badly corroded.

Broken wires or loose battery terminals.

Leaky admission or exhaust-valve.
Seized piston or bearing.
Broken valve-stem or valve-spring.
Batteries exhausted.
Defective spark coil.
Poor contact at the commutator.
Defective insulation of the secondary wires.
Broken piston ring.
Stuck piston.
Defective packing.

Cams, Shape of. The cam shown at M in Figure 28 and of the type in general use for lifting the admission and exhaust valves of gasoline motors, has two serious objections to its extended use. On account of its shape, excessive pounding of the valve on its seat is produced and the time of admission or discharge of the gases from the combustion chamber of the motor very limited, as the valve has only a full lift or opening for a brief instant of time.

FIG. 28



CAMS

The cam illustrated at N removes the objections stated above by being of somewhat larger diameter than cam M, consequently giving an easier lift to the valve and a longer time for the valve to remain fully open. To replace the

ordinary form of cam by this improvement it is in most cases simply necessary to shorten the valve-lifter rod at its upper end, by half the amount of the increase of the cam diameter, the lift of the valve remaining the same as before.

TABLE NO. 8.

DIMENSIONS OF CAP SCREWS.

Diameter of Screw.	Number of Threads per Inch.	Hexagon Head.		Square Head.		Philister Head.	Round Head.
		Short Diameter.	Long Diameter.	Short Diameter.	Long Diameter.		
$\frac{1}{4}$	20	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{7}{16}$	$\frac{5}{8}$	$\frac{3}{8}$	$\frac{7}{16}$
$\frac{5}{16}$	18	$\frac{1}{2}$	$\frac{37}{64}$	$\frac{1}{2}$	$\frac{45}{64}$	$\frac{7}{16}$	$\frac{9}{16}$
$\frac{3}{8}$	16	$\frac{9}{16}$	$\frac{41}{64}$	$\frac{9}{16}$	$\frac{51}{64}$	$\frac{9}{16}$	$\frac{5}{8}$
$\frac{7}{16}$	14	$\frac{5}{8}$	$\frac{23}{32}$	$\frac{5}{8}$	$\frac{29}{32}$	$\frac{5}{8}$	$\frac{3}{4}$
$\frac{1}{2}$	12	$\frac{3}{4}$	$\frac{55}{64}$	$\frac{3}{4}$	$1\frac{1}{16}$	$\frac{3}{4}$	$\frac{13}{16}$
$\frac{9}{16}$	12	$\frac{13}{16}$	$\frac{15}{16}$	$\frac{13}{16}$	$1\frac{5}{32}$	$\frac{13}{16}$	$\frac{13}{16}$
$\frac{5}{8}$	11	$\frac{7}{8}$	1	$\frac{7}{8}$	$1\frac{1}{4}$	$\frac{7}{8}$	1
$\frac{3}{4}$	10	1	$1\frac{5}{32}$	1	$1\frac{7}{16}$	1	$1\frac{1}{4}$
$\frac{7}{8}$	9	$1\frac{1}{8}$	$1\frac{23}{64}$	$1\frac{1}{8}$	$1\frac{39}{64}$	$1\frac{1}{8}$	
1	8	$1\frac{1}{4}$	$1\frac{7}{16}$	$1\frac{1}{4}$	$1\frac{13}{16}$	$1\frac{1}{4}$	
$1\frac{1}{8}$	7	$1\frac{3}{8}$	$1\frac{37}{64}$	$1\frac{3}{8}$	$1\frac{31}{32}$		
$1\frac{1}{4}$	7	$1\frac{1}{2}$	$1\frac{23}{32}$	$1\frac{1}{2}$	$2\frac{9}{64}$		

Cap Screws, Dimensions of—See Table No. 8.

Carbon, Deposit of. The formation of a carbon deposit in the combustion chamber of a gasoline motor is usually accompanied by the smell of unburned or unconsumed gasoline or burned lubricating oil.

The deposit is caused either by the excessive use of lubricating oil or too rich an explosive

mixture. Premature ignition is often the result of a sooty combustion chamber; to prevent it until such time as the obstruction may be removed, run with as little gasoline and as much air as possible to prevent or avoid premature ignition.

Carbon, Use of. Carbon is the positive element or electrode in nearly all commercial forms of dry and primary forms of batteries, it is also used as brushes or current distributers for both dynamos and electric motors. The brushes which convey the current from the storage batteries to the armature of an electric automobile motor are usually of carbon.

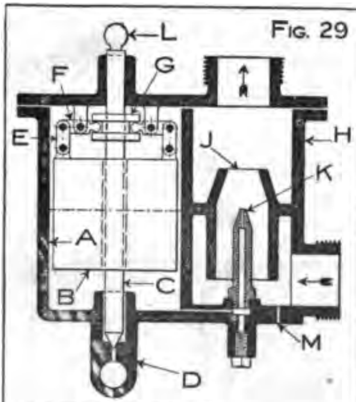


FIG. 29

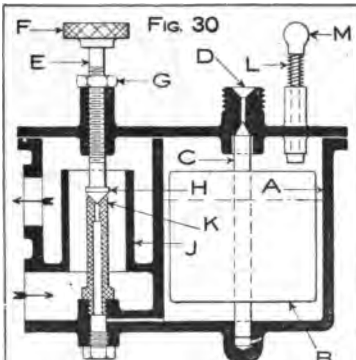
CARBURETER

Carbureters, Construction of. The carbureter shown in the accompanying illustration, Figure 29, is of the jet form of float-feed type.

The chamber A of the carbureter contains the float B, through the center of which passes the stem of the needle-valve C, which keeps the pipe D leading to the gasoline tank normally closed.

When the level of the gasoline in the chamber A falls, the float B, through the links E, small levers F and grooved collar G, raises the stem of the needle-valve C, thus permitting more gasoline to enter the chamber A, until the normal level is again restored.

The mixing-chamber H has an inner tube J, which surrounds the jet or nozzle K. During the admission stroke of the motor-piston, air is drawn into and through the mixing-chamber H, in the direction of the arrows, a small stream of gasoline is in consequence drawn up by suction from the opening in the jet or nozzle K, mixing with the air in the chamber H. The upper end of the stem of the needle-valve C is provided with a small knob L, by which the carbureter may be flushed for the purpose of starting the motor. Any surplus gasoline is carried off by means of the vent M.



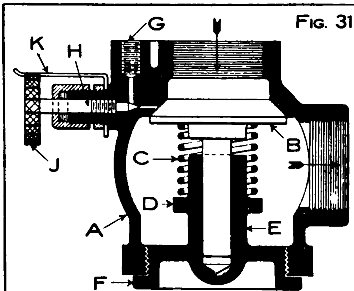
CARBURETER

The spray form of float-feed carbureter shown in Figure 30, has the float B and needle-valve stem C in one piece. When the gas-

oline level in the chamber A is lowered, the needle-valve stem C falls with the float B and allows more gasoline to enter the chamber A, through the opening in the connection at D. The screw E with thumb-piece F and lock-nut G is for the purpose of regulating the volume of the spray at the nozzle K, by means of the cone-shaped point H of the screw E. The nozzle K is surrounded by a tube J, through which the air is drawn by the inductive action of the motor-piston. The carbureter may be flushed by depressing the float with the small plunger M, which is kept normally out of contact with the float by the spring L.

MIXING VALVES. Since the adoption of liquid fuels for explosive motors, numerous forms of carbureters have been designed, with a view to eliminate the complications of the float-feed type. The most practical form of such devices, known as mixing valves, are very suitable for marine or automobile motors, where the speed is not constantly being changed, and are specially adapted for motors that run at a uniform speed. Figure 31 illustrates one form of mixing

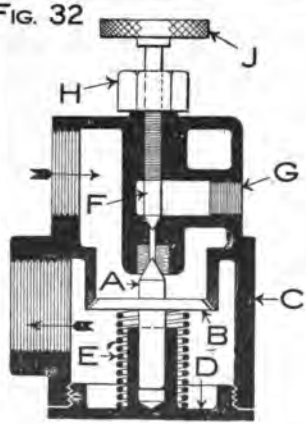
FIG. 31



MIXING VALVE

valve. It consists of a globular chamber A, within which is a valve B, controlled by a spring C carried by the seat D on the valve-stem guide E, which forms a part or portion of the threaded cover F. The gasoline from the supply tank is fed through a suitable pipe screwed into the threaded connection at G, to the opening in the seat of the valve B. The rate of feed of the gasoline is regulated by means of the needle-valve H, with knurled thumb-nut J and lock-spring K. The suction of the motor-piston draws the valve B from its seat and at the same time uncovers the opening in the valve seat leading from the gasoline supply pipe at G and allows of the flow of a small quantity of gasoline.

FIG. 32



MIXING VALVE

The gasoline mixes with the air drawn through the valve opening and the friction of passing around the narrow space between the valve and its seat insures a uniform mixture of gasoline and air.

Another form of mixing valve is shown in Figure 32, in which the gasoline supply is controlled by the cone point on the stem A of the valve B. The cone-point of the valve-stem A entirely closes the opening leading from the supply pipe at G, but keeps the valve B slightly off its seat as shown.

The valve B is held in position by means of the spring E, located around the guide of the valve-stem, which forms a part of the cover D of the valve chamber C.

The amount of gasoline fed to the motor is regulated by the screw F, with thumb-nut J and lock-nut H.

The air is drawn through the carbureters or mixing valves in the direction indicated by the arrows.

Carbureter Troubles. There are several things which may prevent a proper explosive charge from reaching the combustion chamber of a motor. Some of the principal causes may be enumerated as follows:

A leak or crack in the pipe between the carbureter and the admission-valve chamber—Partially or entirely close the air inlet to the carbureter, then try and obtain an explosion from the motor. If it should start, the trouble is probably located and the admission-pipe should be closely inspected for leaks or cracks.

Not enough gasoline—Proceed as above and

if the motor starts, the nozzle in the mixing-chamber of the carbureter should be removed and the opening cleaned by passing a wire through it, the needle-valve opening should be treated in a like manner.

Too much gasoline—Shut off the gasoline supply at the tank and crank the motor. If the motor starts, the trouble is located and the gasoline supply should be regulated, by throttling at the supply tank, or if possible by replacing the nozzle with one having a smaller opening.

Dirt in the gasoline—When filling the gasoline tank always use a strainer-funnel: one that is fitted with a wire-gauze screen of very fine mesh. In the absence of a strainer-funnel, three or four layers of fine linen may be fitted inside an ordinary funnel. A piece of chamois skin also makes an excellent filtering medium. Never use the same funnel for both gasoline and water.

Leak in the float—This may be from the fact that one of the soldered joints has opened, or minute perforations occurred, by corrosion due to the presence of foreign substances in the gasoline. In either case the float will partially or wholly fill with gasoline and sink to the bottom of the float chamber, thus opening the needle-valve and flooding the carbureter. The only remedy for this is a new float.

Poor quality of gasoline—This is generally

indicated by a smoky exhaust with a disagreeable odor, the motor will misfire occasionally and not develop its full power. Gasoline should always be tested with a densimeter when its quality is in doubt and if it does not show at least 76 degrees it should be rejected. In the absence of a testing outfit, a handy and fairly reliable method of testing the fuel is to pour a little of the doubtful gasoline on the palm of the hand. If the gasoline evaporates rapidly and leaves the hand dry and clean, it may be safely used, but if it evaporates slowly and leaves a greasy deposit on the hand, its use should be avoided.

Water in the carbureter—All gasoline contains a slight percentage of water, which, being heavier than the more volatile liquid, settles to the bottom of the gasoline tank and eventually finds its way to the carbureter. This generally happens after a car has been standing for some days and not in use. The gasoline supply should be shut off at the tank and the carbureter emptied by opening the pet-cock usually provided for this purpose at the bottom of the float chamber.

Stale gasoline—The gasoline in the float chamber of the carbureter will lose its strength if the car has been standing for some time not in use—Shut off the gasoline supply at the tank and then empty the float chamber by means of the pet-cock which is usually provided for this purpose. After the float chamber is emptied, close

the pet-cock and turn on the gasoline supply at the tank.

Cold weather—Saturate a piece of waste with some fresh gasoline and insert it in the air-inlet of the carbureter—In extremely cold weather it may be necessary to warm the carbureter and admission-pipe by pouring boiling water over them, but on any account **do not start a bonfire** under the carbureter.

Water in the gasoline—Pour a small quantity of the gasoline on a smooth, unpainted metal surface, the water will separate from the gasoline and collect in small globules, unless the water has been purposely combined with the gasoline by the use of some chemical, at the hands of an unscrupulous dealer—If this is suspected, a small quantity of the gasoline when ignited will burn slowly with a yellowish flame.

Starting crank not turned fast enough—Always remember that a **few quick turns** of the crank will be more likely to start the motor than ten minutes of **slow pumping.**

Carbureters, Types of. Carbureters for gasoline motors are of three types: surface carbureters, in which the air supply is mixed directly with gasoline vapor to form an explosive mixture—spray or jet float-feed carbureters, which, by means of a float, maintain a constant level in the gasoline receptacle and mixing valves, in which the gasoline outlet is opened by means of an air valve.

The surface carbureter is at the present time almost obsolete, being used only on one or two motor-bicycles of European make. The rapid evaporation of the vapor in the surface carbureter, due to the suction of the motor-piston, causes the gasoline after a short time to become thick and syrupy, and if some external source of heat is not supplied to assist in the evaporation it will cease altogether. While the surface carbureter is the most economical of the three forms, it is very irregular and erratic in its action and requires constant manipulation of the air and gasoline vapor cocks to insure at all times an explosive mixture of uniform quality. The float-feed form of carbureter consists of two principal parts: a gasoline receptacle which contains a hollow metal or a cork float, suitably arranged to control the supply of gasoline from the tank or reservoir, and a tube or pipe in which is located a jet or nozzle in communication with the gasoline receptacle—this tube or pipe is called the mixing chamber. The gasoline level is maintained about one-sixteenth of an inch below the opening in the jet in the mixing chamber. The inductive action of the motor-piston creates a partial vacuum in the pipe leading from the mixing chamber of the carbureter to the motor, thereby causing the gasoline to flow from the jet and mixing with the air supply, to be drawn into the cylinder of the motor in the form of an explosive mixture.

Cardan Joint—See Universal Joints.

Chain, Roller. After a chain has been run about 2,500 to 3,000 car miles remove it and thoroughly clean by immersing first in hot water and then in gasoline. Afterwards it should be boiled in mutton tallow for at least one-half hour. The object of boiling the chain in mutton tallow is two-fold, first it gets the grease into a fluid state so that it will enter between the rollers and contact-surfaces of the pins and links and when cold it will exclude all dust or grit from entering therein, besides it forms an excellent lubricant between the rolling surfaces.

The dimensions and strength of standard sizes of roller chain are given in Table No. 9.

TABLE NO. 9.

DIMENSIONS AND STRENGTH OF ROLLER CHAIN.

Pitch of Chain in Inches.	Diameter of Roller in Inches.	Width of Chain in Inches.	Breaking Stress in Pounds.
1	$\frac{9}{16}$	$\frac{3}{8}$ & $\frac{1}{2}$	5,000
$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{1}{2}$ & $\frac{5}{8}$	6,500
$1\frac{1}{4}$	$\frac{3}{4}$	$\frac{5}{8}$ & $\frac{3}{4}$	9,000

Change-speed Gear—See Power Transmission Devices.

Channel-iron—See Structural Shapes.

Chassis. The word chassis since its adoption into the English language is taken to mean the frame, springs, wheels, transmission and in fact

all mechanism except the automobile body. In its original French it does not mean all this, but is strictly restricted to mean the frame, or the frame and springs—see Running Gears.

Chauffeur. This term when literally translated means the stoker or fireman of a boiler. The use of the word has been extended to the operator of a motor car, but does not usually refer to the paid driver, who is generally known as the mecanicien or mechanic.

Circuit-breaker. A circuit-breaker is a device consisting of either a solenoid or an electromagnet which acts automatically to break the circuit of a storage battery charging plant, when a condition of either too low or too high voltage exists.

Circulating Pump—See Pumps.

Circumferences of Circles—See Table No. 6—Areas and circumferences of circles.

Clutches, Friction—See Power Transmission Devices.

Clutch Troubles. Some of the troubles to which a clutch may give rise are:

Slippage of the contact surfaces of the driving and driven members of a clutch, caused by oil or grease getting between the contact surfaces, or need of adjustment to take up wear or lost motion in the working parts—A little Fuller's earth or French chalk will generally cure the slippage if one of the contact surfaces is of leather. If both are metal, a dose of kerosene will in most cases

remove the grease, but on no account use gasoline for this purpose. If the slippage is caused by need of adjustment, so adjust the contact surface of the driving or driven member that the contact surfaces will be closer together than formerly, when apart.

Clutches of the disk or side-drive form usually have the contact surface of the driving member of vulcanized fiber. When badly worn or burnt from too sudden application of the clutch engaging mechanism, slippage will occur, the only remedy for which is new fiber pads.

Clutches of any form, having the contact surface of one of the members leather-covered, which exhibit a tendency to take hold too suddenly, may be remedied by treating the leather surface to a generous application of glycerine or castor oil.

If a cone-friction clutch should stick or seize and all ordinary methods fail to loosen it, with the high speed gear in mesh, push the car backward and forward several times. This will generally free the clutch.

The replacing of the leather on the male member of a cone-friction clutch of the flywheel type is usually a tedious process and one that should be handled by an expert. Owing to the necessity of removing the male member of the clutch from the car, this may in some cases require the complete removal, or at least partial disconnection of the transmission gear.

Always get the new leather from the maker of the car and if possible keep one on hand, to avoid delay when the renewal of the leather becomes a necessity.

Coils—See Electrical Ignition, also Induction Coil.

Combustion Chamber. That part of an explosive motor in which the gases are compressed and then fired, usually by an electric spark, is known as the combustion chamber. The interior of the combustion chamber should be as smooth as possible and kept free from soot or hard carbon deposits such as are induced by excessive lubrication or the use of too rich an explosive mixture.

It will be found to be no small task in designing an explosive motor with the usual form of valve construction and operation, to keep the combustion chamber down to the required dimensions and at the same time have it free from bends or contracted passages between the combustion space and the valve chamber.

Many attempts have been made to obviate this difficulty by making the combustion chamber simply a straight extension or continuation of the cylinder. In this manner both the admission and exhaust-valves can be placed in the cylinder itself and an ideal combustion space secured. This plan has, however, certain disadvantages, from the fact that it not only lengthens the motor, but requires a more complicated form of valve operat-

ing mechanism than if the valve chamber were at the side of the cylinder as is usual.

Combustion Chamber, Dimensions of. If it is desired to ascertain the cubic contents or dimensions of the combustion chamber of an existing motor, they may be found by filling the combustion space with water, then obtaining the weight of the water in ounces, which multiplied by 1.72 will give the capacity of the chamber in cubic inches. If a motor is to be designed with a given bore and stroke, the first thing to do is to decide on the amount of clearance or combustion space at the end of the cylinder for the gases to occupy after compression.

If the combustion space could be made as a continuation or extension of the cylinder bore, it would be an easy matter to determine the required clearance, as it would simply be some fraction of the total piston stroke.

But as the general design of a combustion chamber deviates widely from a plain section or length of a cylinder as above described, being in some cases flat oval, elliptical, semi-spherical and even rectangular in cross section, some other method must be used to calculate the required clearance.

To do this correctly the contents of the combustion chamber in cubic inches must first be ascertained, and then apportioned between the valve chamber or chambers and the clearance

proper which lies directly behind the piston head.

To find the cubic contents of a combustion chamber when the degree of compression in atmospheres is known: Let S be the stroke of the piston in inches and A the area of the cylinder in square inches. If N be the number of atmospheres compression and C the required contents of the combustion chamber in cubic inches, then

$$C = \frac{S \times A}{(N - 1)}$$

Example: Find the cubic contents of the combustion chamber for a motor of 4-inch bore and 5-inch stroke with 4 atmospheres compression.

Answer: Five multiplied by 12.56 equals 62.83, which divided by 3 gives 20.94 as the number of cubic inches required.

Commutators, Care of. Commutators with a make and break form of contact-maker, should have the platinum contacts cleaned at least once a week, with a small piece of fine sandpaper or emery cloth.

Commutators having a rotary wiping form of contact, should have the brass or copper segment thoroughly cleaned in the manner just described, and all grease or dirt removed from the fiber portion of the commutator.

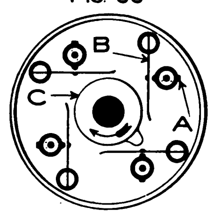
All thumb or lock-nuts and adjusting screws should be carefully gone over, and the condition of the wiring from the battery and coils examined

very closely. Ten minutes spent in this manner once a week may save long delays and much laborious work at some future time.

Commutators, Forms of. The commutator of the ignition system of a multi-cylinder gasoline motor has a three-fold use: To switch the battery current in and out of the electrical circuit at the proper time—To transfer the battery current successively from one coil to another—To vary the point or time of ignition of the explosive charge in the motor cylinder.

The commutator shown in Figure 33 is for a four-cylinder motor and is designed for use with induction coils without vibrators, which are known as single-jump spark coils. The studs of the screws A and springs B are carried by insulated bushings located in the back of the commutator case. The nose of the cam C successively engages with the springs, causing them in turn to make contact with their respective screws. The battery and coil circuit is completed through the screws A, and a ground to the cam C, by means of the springs B, when in contact with their respective screws and the cam.

FIG. 33



COMMUTATOR

This device is said to cause a good spark at

the plug on account of the quick break between the spring and the screw, the electrical circuit being broken the instant the spring leaves the screw and before the cam has allowed the spring to resume its normal position. This form of commutator cannot be short-circuited by oil or dirt getting between the spring and the screw, as the spring B only forms a part of the electrical circuit when in contact with both the cam C and the screw A.

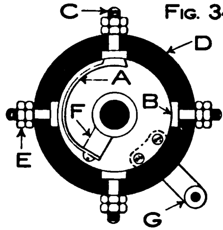
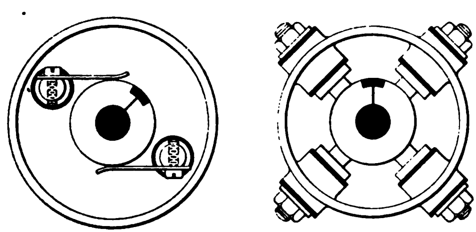


FIG. 34
COMMUTATOR

Another form of commutator for a four-cylinder motor is illustrated in Figure 34, which has a rotary spring contact-maker A, which engages successively with the heads B of the screws C. The screws are spaced equidistant around the fiber ring D, which also forms the case of the commutator and are held in position by the lock-nuts E. The spring contact-maker A is attached to a hub F on the cam shaft of the motor. The time or point of ignition may be varied by moving the commutator case about its axis by means of a rod attached to the arm G.

Figure 35 shows two commutators of very similar construction. The one at the left in the drawing is for a two-cylinder motor and has

flat spring-steel contact-makers. The commutator shown at the right of the drawing is for a four-cylinder motor and instead of having flat spring contact-makers, it has either carbon or copper contact-brushes, which are held against the commutator by short coil springs in the insulated bushings located around the periphery of the commutator case. The commutator is made of vulcanized fiber with a short brass or copper



COMMUTATORS FIG. 35

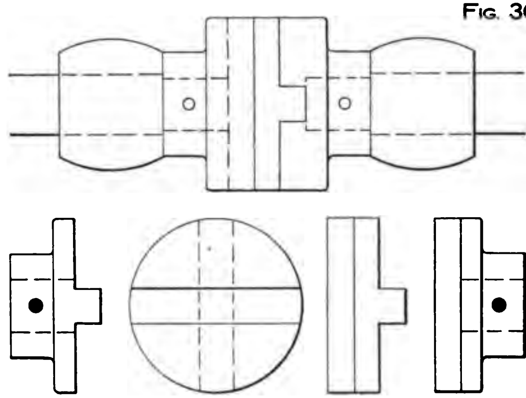
segment, which is grounded to the cam shaft as shown.

The forms of commutators illustrated in the drawings may be constructed for use with a motor of any number of cylinders, by increasing or decreasing the number of contact-makers located around the commutator—see also Electric Motors.

Compensating Joints. On account of the distortion of the frame or running gear of an automobile, due to unequal spring deflection and irregularities of the road surface, means should

be provided to insure flexible joints or connections between the various rotating parts of the mechanism of a car. The device shown in Figure 36 is not susceptible to any great amount of angular distortion, but will transmit power with a practically uniform velocity, with the axes of the shafts considerably out of alignment in vertical or horizontal parallel planes.

FIG. 36



COMPENSATING DEVICE

The form of compensating joint shown in Figure 37 may be operated with the axes of the shafts at an angle to each other, or with the shafts out of alignment with each other in vertical or horizontal parallel planes and has quite a range of operation with either condition. Both forms of the device require to have bearings on either side, as shown, to insure their proper working.

Compressed Air—See Air, Properties of.

Compression, Advantages of. The compression pressure of an explosive motor should be as high as is possible, without danger of reaching the degree of compression at which premature or self-ignition of the charge would occur.

A high degree of compression is of great advan-

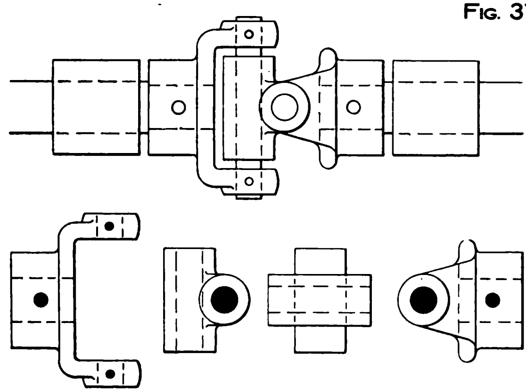


FIG. 37

COMPENSATING JOINT

tage, but it is not generally known that during compression there is a loss of heat from the gases to the walls of the motor cylinder. If the time or period of contact of the gases with the cylinder walls were less, the heat losses would be smaller. Hence the mean temperature of the gases during the compression stroke of the motor increases with the motor speed and consequently the gases

ignite far more readily when the motor is running at a high rate of speed, than when running slowly or being operated by hand.

The higher the compression, therefore, the quicker the ignition and consequent expansion of the gases take place, thereby causing them to attain a greater initial pressure, on account of the lesser heat losses through the cylinder walls. As it takes a certain length of time to dissipate or radiate a certain amount of heat, it follows as a natural sequence that the shorter the time occupied by the burning gases to attain their highest pressure, the smaller the heat losses by dissipation or radiation. The principal gain by the use of high compression is secured from the fact that the motor may be run at a greater number of revolutions per minute, thus having more working strokes or power impulses and hence greater power, than if using a lower degree of compression and consequently slower speed.

Compression, How to Calculate. The compression in atmospheres of a motor may be readily found by dividing the cubic contents of the piston displacement by the cubic contents of the combustion chamber in cubic inches, and then adding one to the result.

To ascertain the compression in atmospheres of a motor, when the cubic contents of the combustion chamber are known: Let S be the stroke of the piston in inches and A the area of the

cylinder in square inches. If C be the contents of the combustion chamber in cubic inches and N the required compression in atmospheres, then

$$N=\left(\frac{S\times A}{C}\right)+1$$

Example: Find the compression in atmospheres of a motor of 4-inch bore and 6-inch stroke, whose combustion chamber has a capacity of 18 cubic inches.

Answer: Six multiplied by 12.56 equals 75.36, which divided by 18 gives 4.19, and 4.19 plus 1 equals 5.19, or the compression in atmospheres required.

If it is desired to ascertain the compression in atmospheres of a motor, the combustion chamber of which is of such shape that its dimensions cannot be accurately calculated, its cubic contents may be found by filling the combustion chamber with water, and after removing the water, ascertaining its weight in ounces, and then multiplying the result by 1.72. This gives the capacity of the combustion chamber in cubic inches. The compression of the motor can then be readily calculated from the formula given herewith—see also Air, Properties of Compressed.

Compression, How to Test for Leaks in. To discover if there are any leaks in the compression of a gasoline motor, a small pressure gauge reading up to 75 pounds should be fitt

into the spark plug opening in the combustion chamber by means of a reducing bushing. When turning the starting crank of the motor slowly the gauge should indicate at least 60 pounds per square inch if the compression is in good condition.

To test for leaks, fill a small oil can with soapy water and squirt round every joint where there may be a possible chance for leakage. Get an assistant to turn the crank and watch for bubbles at the joints.

If the joints are all tight, next examine the condition of the admission and exhaust-valves and if either of them needs regrinding, it should be done, first with fine emery powder and oil, then finished with tripoli and water.

When the valves have been ground to a perfect fit, if the compression still leaks, the piston rings should be examined, as the trouble will be found to be with them—see Piston Rings.

Condenser, Use of. A condenser is used in connection with a Rumkorff or jump-spark form of induction coil to take up or absorb the static charge of electricity, occasioned by the self-induction or electrical reaction in the primary winding of the coil upon the breaking of the battery circuit by the interrupter or vibrator. This static charge is given up or discharged into the primary winding of the coil along with the battery current upon the closing of the circuit, thus

intensifying the action of the secondary winding of the coil in a great degree.

By absorbing the static charge of electricity the condenser helps to decrease the spark or arc between the platinum contact points of the interrupter or vibrator, thereby lengthening the life of the platinum contacts by reducing the erosive action of the induced current spark. A jump-spark coil very often refuses to work properly on account of the condenser connections having become loose—see Electrical Ignition.

Construction of a Gasoline Motor—See Gasoline Motor Construction.

Contact-breaker. Some forms of high speed gasoline motors with an induction coil of the single-jump-spark type, have a device known as a contact-breaker to open or break the electric circuit of the battery and coil, at the proper time for the passage of the arc or spark at the points of the spark plug. On account of the extremely high speed of such motors, and to allow time for the magnetism or magnetic flux in the core of the coil to attain a density sufficient to produce a good spark at the plug points, it is found necessary to keep the battery and coil in a closed circuit, except during the brief interval necessary for the passage of the spark at the plug points.

Figure 38 illustrates one form of contact-breaker. The left-hand end of the double lever is kept in contact with the lower end of the

insulated pin, by means of a short spring immediately below it. When the nose of the cam engages with the roller in the fork or jaw at the right-hand end of the double lever, instant separation of the nose of the insulated pin and the left-hand end of the double lever takes place, breaking the electric circuit and causing a spark to occur at the points of the spark plug.

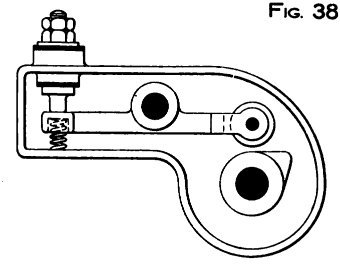


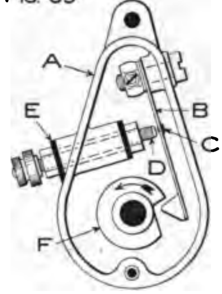
FIG. 38
CONTACT BREAKER

The electric circuit of the battery and coil is completed by one wire being connected with the lock-nuts on the upper end of the insulated pin and the other wire grounded on the case of the contact-breaker.

Contact-maker. One of the simplest methods of electric ignition for explosive motor use is that known as the single-jump-spark system, with which a plain induction coil without a vibrator or trembler is used. The secondary spark is produced by means of a mechanical device operated by the cam shaft of the motor. The devices illustrated and which are known as contact-makers, cause a spark to arc or jump between

the points of the spark plug in the combustion chamber of the motor.

Fig. 39



CONTACT MAKER

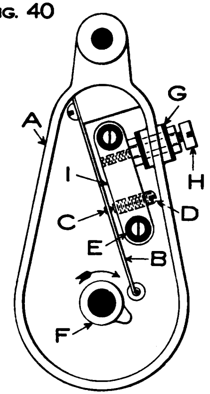
Figure 39 shows one form of contact-maker. The case A is usually attached to the gear box of the motor. Attached to a boss on the inside and near the upper end of the case is the trembler B, consisting of a flat steel spring with a nose at its lower end. Near the center of the spring is a platinum contact-point C. On the opposite side of the case is a bushing with insulation E, carrying the screw D, which is so adjusted that it does not quite contact with the platinum point C of the trembler. As the cam F revolves in the direction indicated by the arrow, it comes in contact with the nose of the trembler B, and pushes the platinum point C still further away from the screw D. Shortly before the cam has arrived at the position shown in the drawing, it has released the nose of the trembler, allowing it to fall; this action produces a vibrating effect, opening and closing the circuit repeatedly and with great rapidity, between the point C and screw D.

This is supposed to cause a stream or succession

of sparks to occur between the plug points in the combustion chamber of the motor. In practice, however, and at a high rate of speed, only a single spark occurs.

Another form of contact-maker is shown in Figure 40. The trembler B has a small roller upon its lower end which at the proper time is engaged by the nose of the cam F. The screw D is carried in a metal block I, which is attached to the back of the case A by suitable insulating bushings E. The screw H in the insulated bushing at G, makes the electrical connection from the coil and battery, through the block I and screw D, to the platinum contact C on the trembler B. The operation of this device is precisely the same as that of the one shown in Figure 39.

FIG. 40



CONTACT MAKER

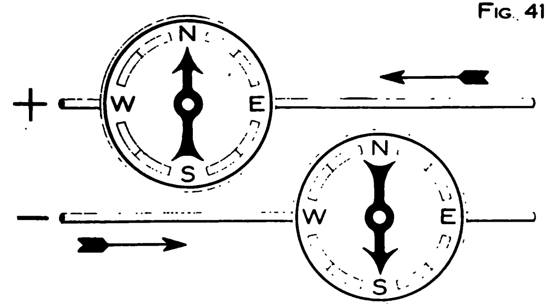
Coupling, Flexible—See Universal Joints.

Current, Commutation of Secondary. There have been numerous devices made for this purpose, but it is almost an impossible proposition to switch the secondary current properly on account of its great intensity. It will arc around

almost any form of commutator that could be devised of practical working dimensions.

Current, Direction of. The direction of a current of electricity flowing in a wire may be readily ascertained by reference to Figure 41. Place an ordinary pocket compass above the wire and in the position shown. If the needle points to the North pole of the compass, the

FIG. 41



POLE FINDER

current will be flowing in the wire in the direction indicated by the arrow in the upper view, and the end at the left will be the Positive pole or terminal of the wire. If on the other hand the needle points to the South pole of the compass, the current will be flowing in the opposite direction as indicated by the arrow in the lower view in the drawing, and the end at the left will in this case be the Negative pole or terminal of the wire—see also Polarity.

Cylinder-jacket—See Water-jackets.

Cylinder, Method of Boring a. A good way to bore a cylinder is to make a boring-bar to fit in the drill socket of a back-geared drill press and a brass or phosphor bronze bushing to fit in the center hole of the table of the drill press. The cylinder can be clamped to the table of the drill press by its flange and bored out with a cutter set in the boring bar. Not less than three, and preferably four cuts, should be taken to make a good job. A mandril should then be made with two flanged hubs, one of which should be fastened to the mandril and the other turned slightly taper so as to make a snug fit in the cylinder bore when in place. The ends of the cylinder can then be finished on the mandril and a perfect job will be the result. In case a back-geared drill press is not handy the cylinder can be clamped to the carriage of the lathe, bored out with a bar in the lathe centers and the ends finished in the manner above described, but it is a much slower job than in a drill press. The cutter for the bar should be made from a piece of round tool steel not less than five-eighths of an inch diameter. It can then be readily adjusted to any desired angle to obtain the best cutting effect.

Cylinder, Scratched—See Scratched Cylinder.

Decimal Fractions of an Inch. See Table No. 10.

Table No. 10.

Decimals of an Inch for Each $\frac{1}{32}$.

$\frac{1}{32}$ds.	Decimal	Fraction	$\frac{1}{32}$ds.	Decimal	Fraction
1	.03125		17	.53125	
2	.0625	1-16	18	.5625	9-16
3	.09375		19	.59375	
4	.125	1-8	20	.625	5-8
5	.15625				
			21	.65625	
6	.1875	3-16	22	.6875	11-16
7	.21875		23	.71875	
8	.25	1-4	24	.75	3-4
9	.28125		25	.78125	
10	.3125	5-16			
			26	.8125	13-16
11	.34375		27	.84375	
12	.375	3-8	28	.875	7-8
13	.40625		29	.90625	
14	.4375	7-16	30	.9375	15-16
15	.46875				
			31	.96875	
16	.5	1-2	32	1.	1

Densimeter, Use of. The scale generally in use for indicating the densities of liquids is that of Baume. On this scale the zero point corresponds to the density of a solution of salt of specified proportions, while 10 degrees corresponds to the density of distilled water at a specified temperature.

Figure 42 shows the form of densimeter generally used for testing gasoline.

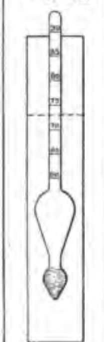
Gasoline for explosive motor use should test at least 76 degrees Baume.

Deposit of Carbon in Combustion Chamber—See Carbon, Deposit of.

Diagram, Indicator—See Indicator Diagrams.

Diagram, Wiring, for a Single Cylinder Motor. Diagram No. 2 shows a method of wiring for a single cylinder motor, using two sets of dry batteries—a storage battery and a set of dry batteries—or a set of dry batteries and a generator. By moving the switch finger, either the generator or the battery may be used as desired, or both cut out.

FIG. 42



DENSIMETER

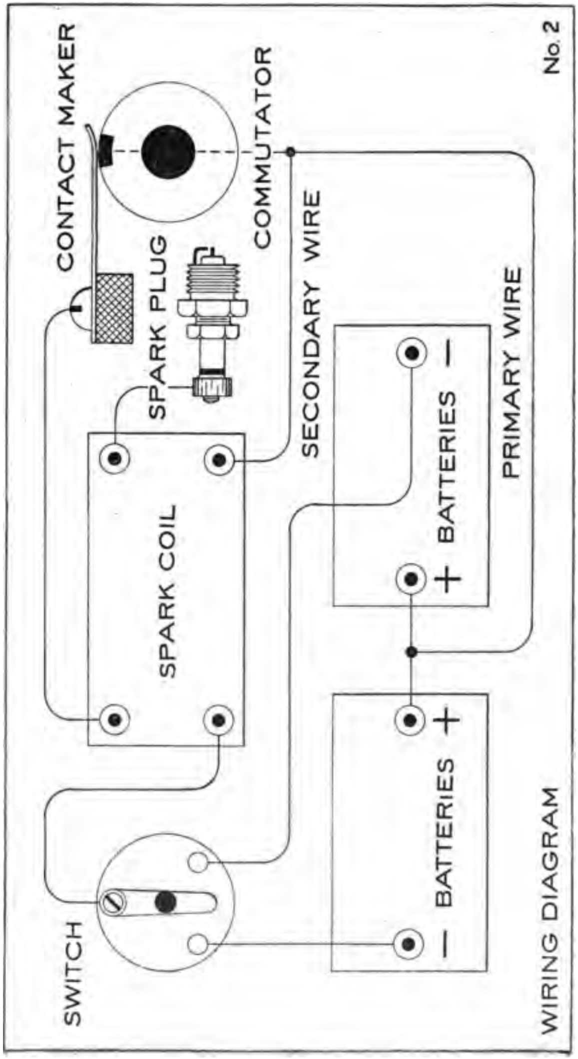
Differential Gear — See Power Transmission Devices.

Don'ts. In the first place don't forget to ascertain the fact that the ignition mechanism is retarded before cranking the motor. Many a sprained wrist and not a few cases of broken heads or arms have been caused by the neglect of this simple precaution. It is a good plan to have the ignition-control spring so actuated that in its normal position it is always retarded.

If the motor should not happen to start the first time, don't forget to keep out of the way of the crank when the motor is stopping. It might take a turn backwards and take the crank with it.

Don't forget to close the battery switch before starting the motor.

Don't allow the motor to stand in such a


CONTACT MAKER
COMMUTATOR
SPARK PLUG
SECONDARY WIRE
SPARK COIL
BATTERIES
PRIMARY WIRE
BATTERIES
SWITCH
WIRING DIAGRAM
No. 2

position that with the battery connected, the vibrator of the spark coil will work. It is almost the same as a short-circuit, and will run down the battery rapidly.

Don't use a match or a small torch to inspect the carbureter. It sometimes leads to unexpected results.

Don't forget to fill the gasoline tank before starting.

Don't smoke while filling the gasoline tank.

Don't take out all the spark plugs when there is nothing the matter, except that there is no gasoline in the tank.

Don't forget to always have an extra spark plug on the car.

Don't allow the motor to race or run fast when out of gear. If the car is to be stopped for a few minutes, without stopping the motor, retard the ignition and also throttle the charge, so that the motor will run as slowly as possible.

Don't fill the gasoline tank too full, leave an air space at the top or the gasoline will not flow readily.

Don't have any open hole in the gasoline tank. When the car is washed water may run in this hole, mix with the gasoline and cause trouble.

Don't put grease in the crank case of the motor, it will clog up the oil holes and prevent the oil from circulating.

Don't fill the gasoline tank by lamp or candle light, something unexpected may happen.

Don't keep on running when an unusual noise is heard about the car, stop and find out what it is.

Don't start or stop too suddenly, something may break.

Don't pour gasoline over the hands and then rub them together. That rubs the dirt into the skin. The proper way to do is to saturate a towel with gasoline and then wipe the dirt off.

Don't forget to examine the steering gear frequently.

Don't fail to examine the pipe between the carbureter and the admission-valve occasionally. The pipe connections sometimes get loose and allow air to enter and weaken the mixture.

Don't forget to see that there is plenty of water and gasoline in the tanks.

Don't fail to clean the motor and all the wearing parts of the car occasionally.

Don't forget to oil every part of the motor where there is any friction, **except the valve stems.**

Don't spill the gasoline on clothing and then strike a match to light a pipe, some one may be sorry afterwards.

Don't go out for a run without a complete equipment of tools, extra parts, gasoline, and tire repair outfit, or a late return may be expected.

Don't let a willing bystander fill up the gasoline tank with water.

Don't leave the water in the circulating system on a frosty night, except with 40 per cent of glycerine in it, and never when below zero.

Don't start away with the brake on and wonder why the motor is not working well, and in conclusion,

Don't let the starting handle fly off and hit somebody on the chin.

Driving-wheels, Large versus Small. The larger the wheels, the less power should be required to drive a car. Theory shows that the road resistance decreases in proportion as the wheel diameter gets larger. The result of experiments to verify this do not show quite such favorable results, but a gain almost in proportion to the square root of the wheel diameter has been obtained. The principal reasons why large wheels are not more used are as follows:

The center of gravity of the car is raised and makes the car less stable in turning corners. They are more expensive and more liable to injury than wheels of smaller diameter. They increase the cost of the tires enormously. They make access to the seats more difficult on account of the increased height of the car.

Dry Batteries—See Batteries, Dry and Primary.

Dynamo—See Generator.

Dynamometer. A dynamometer is a form of equalizing gear which is attached between a source of power and a piece of machinery when it is desired to ascertain the power necessary to operate the aforesaid machinery with a given rate of speed.

Efficiency, Electrical—See Electrical Horse-power.

Efficiency of a Gasoline Motor. In text-books the efficiency of a motor is usually considered as the relation between the heat-units consumed by the motor and the work or energy in foot-pounds given out by it. If the heat-units (which are measured by the quantity of fuel supplied to the motor) be large compared to the work or energy given out by the motor, its efficiency is small.

At the present time the quantity of liquid fuel consumed by an explosive motor for automobile use is of secondary importance. The fuel economy of a motor is important, but it does not usually occupy the first place in automobile construction. The consideration of primary importance is to obtain the maximum amount of power from a motor of minimum weight. As only about one-fifth of the heat-units consumed by an explosive motor are utilized or given up in the form of work or energy, there is consequently room for great improvement.

The power for weight efficiency of a motor increases almost in proportion to the speed with

high speed explosive motors, but the fuel efficiency of a motor decreases with the speed beyond certain limitations.

Efficiency of Power Transmission—See Transmission of Power.

Electrical Charging Outfits—See Batteries, Dry and Primary, Battery Charging Outfit and Storage Battery Charging.

Electrical Horsepower. One electrical horsepower is equal to the current in amperes multiplied by the electro-motive force or voltage of the circuit and divided by 746.

Let C be the current in amperes and E the voltage of the circuit. If E. H. P be the required electrical horsepower, then

$$E.H.P = \frac{E \times C}{746}$$

In practice with motors of small power, 1,000 watts are necessary to deliver one mechanical or brake horsepower at the driving shaft of the motor.

If the actual or brake horsepower of an electric motor be known, the efficiency of the motor may be readily found by the following formula:

If E be the voltage of the circuit and C the current in amperes consumed by the motor, let B. H. P be the [illegible] horsepower of the motor and e the [illegible] he motor, then

$$[illegible] \frac{P \times 746}{\times C}$$

Table No. 11 gives the electrical horsepower of motors with voltage from 20 to 100 volts, and current strengths from 10 to 80 amperes.

The mechanical efficiency of a motor may be found by use of the table as follows:

Example: Required the mechanical efficiency of a 40-volt, 60-ampere motor, which is rated by its maker as of 3.25 horsepower—the motor when under full load using 80 amperes.

Answer: Reference to the column in the table corresponding to 40 volts and 60 amperes gives 3.22, while the 80 ampere column gives 4.29. Then 3.22 divided by 4.29 gives 0.75, or 75 per cent, as the mechanical efficiency of the motor.

TABLE No. 11.

ELECTRICAL HORSEPOWER OF MOTORS.

Voltage.	Current in Amperes.							
	10	20	30	40	50	60	70	80
20	.29	.54	.79	1.07	1.34	1.61	1.88	2.14
40	.54	1.07	1.61	2.14	2.68	3.22	3.75	4.29
60	.79	1.61	2.41	3.22	4.02	4.82	5.56	6.43
80	1.07	2.14	3.22	4.29	5.36	6.43	7.50	8.58
100	1.34	2.68	4.02	5.36	6.70	7.94	9.38	10.72

Electrical Ignition. There are two methods of producing an electric spark for ignition purposes: The first, by means of an induction coil which has only a single winding, composed of a few layers of insulated copper wire of large size,

wound upon a bundle of soft iron wires, known as the core. The second, by the use of an induction coil with a double winding upon its core. The inner winding being composed of a few layers of insulated wire of large size, as in the coil just described, and an outer winding consisting of a great many layers of very small insulated copper wire, in fact, several thousand feet in length.

The coil first described is known as a **primary spark coil,** from the fact that the spark or arc is produced by the direct effect of the battery or generator current flowing in the coil. This form of spark will not arc or jump across a space between two points, but simply occurs between the contact points on the breaking of the contact.

The second form of induction coil is commonly known as a **secondary spark coil,** because the arc or spark is produced in the secondary winding of the coil, and will jump or arc across a space between two fixed points, without the points first coming in contact.

INDUCTION COIL. Induction is the process by which a body having electrical or magnetic properties calls forth similar properties in a neighboring body without direct contact. This property is known as self-induction and is caused by the reaction of different parts of the same circuit upon one another, due to variations in distance or current strength. The current produced by an

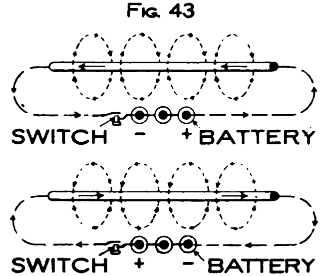
induction coil has a very high electro-motive force and hence great power of overcoming resistance.

The average user of an automobile is well aware that without the battery and the spark coil the motor would not operate. He has learned that, when the spark fails, there are certain forms to be gone through to ascertain the cause of trouble, but as there are other difficulties, it is desirable that more should be known of this important subject.

If a current of electricity be caused to flow through a straight conductor forming a part of a closed electric circuit, lines of force, commonly called magnetic whirls or waves, are induced in the air and rotate around the conductor.

If the current of electricity be flowing in the circuit and through the straight conductor from right to left, as shown in the upper view in Figure 43, the lines of force or magnetic whirls will rotate around the conductor from left to right, or in the direction of the hands of a clock.

FIG. 43



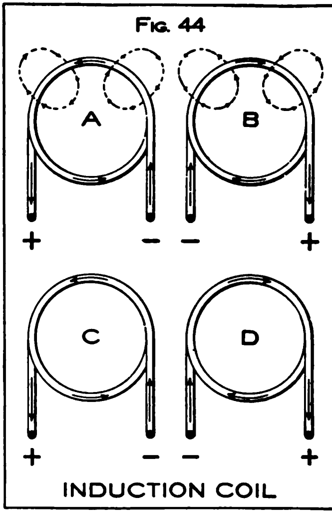
INDUCTION COIL

On the other hand, if the conditions be reversed and the current flows from left to right the lines

of force or magnetic whirls will rotate from right to left, as shown in the lower view in Figure 43. The direction of rotation of these lines of force or magnetic whirls may be positively determined by the use of a galvanometer, an electric testing instrument having a needle similar in appearance to that of an ordinary compass. Upon placing this instrument in the path of the lines of force and making and breaking the battery circuit by means of the switch, the needle of the galvanometer will be deflected from its zero point in the direction of the rotation of the lines of force. If the direction of the flow of the electric current through the circuit be changed by reversing the poles of the battery, the needle of the galvanometer will be deflected from its zero point in the opposite direction. Whether these lines of force or magnetic whirls rotate continuously around the wire has not been demonstrated. They rotate with sufficient force to be tested by the galvanometer only until the electric current in the closed circuit has reached its maximum value after closing the circuit: that is to say, only during the infinitesimal space of time required by the current to reach its full value or power.

If, instead of a straight conductor, a loop of insulated wire, in the form of a circle, be utilized for the passage of the current, as at A and B in Figure 44, the lines of force will still rotate around the wire as shown, their direction being depend-

ent on the direction of the electric current. If the electrical circuit be provided with a current reverser, or device for changing the battery connections in the circuit from positive to negative and vice versa, the lines of force can be made to rotate rapidly first in one direction and then in the other, as indicated in Figure 43.



Suppose this loop of insulated wire be composed of a great number of turns, it then becomes a coil or closed helix, and as all the lines of force cannot pass between the turns of the electrical conductor forming this helix they must pass completely through the helix instead of rotating around a single loop, as at A and B, Figure 44. If the current flows through the conductor in the direction indicated by the arrows, at C in Figure 44, and over and around the coil in the direction shown, the lines of force will flow through the coil towards the observer, and complete their path or circuit through the air, returning into the coil

at the opposite end. If the current be reversed and flow around the coil in the direction of the hands of a clock, the lines of force will flow through the coil in the opposite direction, that is, away from the observer, as at D, Figure 44.

This form of coil or closed helix may be designated as the primitive form of an electro-magnet. When forming part of a closed electric circuit it possesses the property of magnetizing a bar of wrought iron placed within it. If a short round bar of wrought iron be placed a short distance within the coil and the battery circuit be closed, the iron bar will, if the current is sufficiently strong, be sucked or drawn into the center of the coil, and a considerable effort will be required to withdraw it.

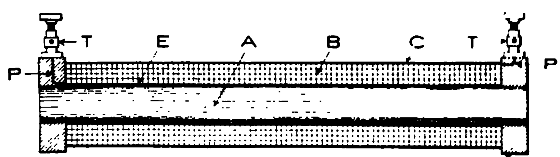
The object of the bundle of soft iron wires, which form the core of any form of spark coil, is to increase the magnetic effect of the lines of force or magnetic flux, or rather to reduce the resistance to their passage through the coil.

As the resistance of air to the flow of the lines of force is about 100,000 times greater than that of wrought iron, the introduction of the iron core into the coil increases its magnetic effect enormously.

As has been previously stated, when a current of electricity flows through a conductor or wire forming a coil or closed helix, lines of force are induced and flow through, and also around the

exterior of the coil. In a like manner, when the electric circuit is broken, the lines of force suddenly reverse their direction, and travel through the coil with a tremendous velocity until they reach a state of neutralization. During this reverse travel of the lines of force through the coil, a current of electricity is induced in the winding of the coil, but in the opposite direction to that in which the battery current was flowing. The effect of this induced current, which is of far greater intensity or pressure than the battery current which induced it, is to form an arc or spark at the breaking point in the circuit.

PRIMARY SPARK COIL. Figure 45 shows a vertical longitudinal section through an induction coil of the form first described, and known as a



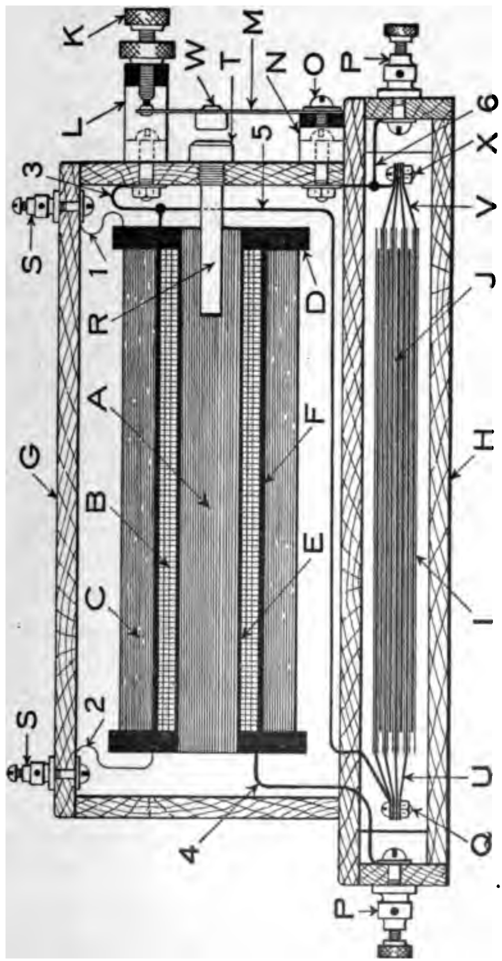
WIPE SPARK COIL FIG. 45

wipe or touch spark coil. It consists of two principal parts, a core, made of a bundle of soft iron wire, and a coil of wire around this core composed of from 3 to 5 layers of turns of insulated copper wire, varying in diameter from No. 16 to No. 12, B. & S. Gauge, according to the

battery conditions under which the coil has to operate. The iron core may vary from three-eighths of an inch in diameter and 6 inches long, to three-fourths of an inch in diameter, and 12 to 15 inches long, depending upon the intensity and capacity of the spark required. Reference to the drawing will show that the core A has upon its ends wood or fiber washers D. They may be square or round. Upon the portion of the core between the washers is a paper tube E, upon which the wire forming the primary winding is wound. The ends of the wire forming the coil and shown at P are connected to the binding posts or terminals indicated by the letter T, and located on top of the washers D. The wire B, forming the primary winding, is usually provided with an outer casing, as shown at C, to protect it from water and grease.

The form of induction coil above described is generally used for ignition purposes on gas and gasoline motors fitted with a mechanical make and break form of spark, which is located within the combustion chamber of the motor itself.

Secondary Spark Coil. Figure 46 shows the secondary or jump-spark form of coil. It is composed of an iron core and a primary winding similar to that described in conjunction with Figure 45, with the addition of an outer winding of many turns of fine wire. This wire, of very small size, is known as the secondary winding,



JUMP SPARK COIL

FIG. 46

varying in diameter from No. 36 to No. 40. B. & S. Gauge, and in length from 5,000 to 10,000 feet. In the drawing the induction coil is shown equipped with an electro-magnet make and break or vibrator device, which is the form mostly used for ignition purposes. The other form, known as the plain jump-spark coil, has a mechanically operated make and break device attached to the motor to operate the coil.

The arc or spark produced at the breaking point of the electrical circuit in which the primary winding of the coil is connected is not utilized for ignition purposes in this type of coil. When the circuit is broken the sudden reaction or backward flow of the lines of force or magnetic flux in the iron core produce an induced current in the secondary winding, but in the opposite direction to that of the battery current. This induced current is of so much greater intensity and velocity than that induced in the primary winding by this same reaction, that the arc or spark induced in the secondary winding of the coil will jump across a space from one end of the wire to the other, varying from $\frac{1}{8}$ inch to as much as 8 or 10 inches in length, dependent upon the length of wire in the secondary circuit, the electro-motive force of the battery and the frequency of the interruptions or number of times per minute the electric circuit is made and broken.

In the drawing A is the core, B the primary

winding and C the secondary. The two coils are held in place upon the core by the washers D. The primary wire B is wound over a paper tube E, and the secondary wire C is insulated from the primary wire by a mica insulating tube F. The coil proper is enclosed in a wood case G.

The terminals or binding posts on top of the case G are connected with the ends of the secondary wire 1 and 2. The secondary terminals are plainly indicated by the letter S. In the base H of the coil case is the condenser J, an essential feature of this form of coil, which utilizes the induced primary current to produce a greater reactive energy in the secondary winding.

At the right-hand end of the coil and outside the casing G is located the electro-magnetic vibrator or trembling device, which automatically makes and breaks the primary circuit. The end 3 of the primary wire is connected with the contract screw K through the bracket L. The spring M, carried by the bracket N, with screw O, is connected with the terminal or binding post P, immediately beneath it, by the wire 6 through the bracket N. The end 4 of the primary wire is connected with another terminal or binding post P, at the other end of the base of the coil. The condenser J is connected across the contact points of the screw K and the spring M, by the wires 5 and 6 and screws Q and X. The condenser is composed of a number of sheets of tinfoil V, laid

between sheets of specially insulated paper I, with the opposite end of every alternate sheet of tinfoil projecting from the paper insulation, as shown. These projecting ends are connected together and by the wires 5 and 6 to the contact screw K and spring M, respectively, as previously described.

When the coil is connected in or forms part of a closed electric circuit by means of the terminal or binding posts P, on the base of the coil, the current flows through the primary winding B. This instantly produces a high degree of magnetism in the core A, and the pole-piece T of the core extension R becomes strongly magnetic and attracts the iron button W of the spring M. This draws the spring M away from the end of the screw K, and in consequence breaks the electric circuit. This results in the demagnetizing of the pole-piece T and the consequent return of the spring M to its normal position in contact with the end of the screw K. So long as the electric circuit remains closed this operation is repeated at a very high rate of speed. The effect of this continuous operation of the coil is to produce an intermittent current in the secondary winding of high intensity and velocity. If wires are placed in the holes in the small terminals or binding posts on the top of the coil and brought within a short distance of each other, a stream of sparks will pass from one wire to the other in

a peculiar zigzag manner and emit a loud, crackling noise, accompanied by a peculiar odor, caused by the formation of ozone through the electro-chemical action of the spark.

Under ordinary circumstances the arc or spark which occurs on the breaking of the contact between the platinum points of the screw K and spring M would not be utilized, but by means of the condenser in the base, which is connected to these parts, as before described, the static charge of electricity generated by this action is stored in the condenser. When the contact is again made this stored electric energy is given up or discharged by the condenser and flows through the primary winding of the coil in connection and in the same direction as the battery current and increases the magnetic effect of the core A enormously.

When the coil is used in connection with a gas or gasoline motor a form of ignition device known as a spark plug is used. This is connected with the secondary terminals and screwed into the combustion chamber of the motor. A form of circuit breaker upon the motor is used to make and break the electric circuit at the desired point, and the resulting arc or spark inside the combustion chamber ignites the charge of vapor.

This style of coil is sometimes used without the electro-magnetic vibrator, and a mechanical make and break device, actuated by the motor, is

used instead, producing as a rule only a single spark.

To remove any doubt as to the origin of the secondary or jump-spark form of induction coil, it may be here briefly stated, that it was invented by Rumkorff in the year 1851, long before the inception of the automobile.

Electrical Rules and Formulas. Force is any cause of change of motion of matter. It is usually expressed by volts, pounds or other units.

Resistance is a counter-force or whatever opposes the action of another force.

Work is force exercised in traversing or crossing a space against a resistance or counter-force. Force multiplied by space or distance represents work in foot-pounds.

Energy is the capacity for doing work, and is measured by the work done.

The cause of a manifestation of energy is force. If this be electro-motive energy or electric energy in current form it is called **Electro-motive force.** The practical unit of electro-motive force is the **Volt.**

When electro-motive force does work in a closed electric circuit a current is produced. The practical unit of current is called the **Ampere.**

A current of electricity, when flowing in a closed electric circuit, passes through some substances more easily than through others.

The relative ease of passage of the electric

current is known as conductance. In practical calculations its reciprocal, which is called resistance, is generally used. This practical unit is known as the **Ohm.**

A current of one **Ampere** is maintained by one **Volt** through a resistance of one **Ohm.**

Ohm's Law may be generally stated under the following heads:

The current is in direct proportion to the voltage of the circuit, and inversely proportional to its resistance.

1. The current is equal to the voltage divided by the resistance of the circuit.

2. The voltage is equal to the current multiplied by the resistance of the circuit.

3. The resistance of the circuit should equal the voltage divided by the current required.

Let C be the current in amperes flowing in the closed electric circuit, and E the electro-motive force or voltage, if R be the resistance of the circuit when closed, then

$$C=\frac{E}{R} \qquad (1)$$

$$V=C\times R \qquad (2)$$

$$R=\frac{E}{C} \qquad (3)$$

Example: What current will pass through a primary spark coil having a resistance of 1.5 ohms, with a storage battery of 6 volts in the coil circuit?

Answer: By Formula 1, 6 volts divided by 1.5 ohms gives 4 amperes as the current which will pass through the coil.

Example: The lamp of a small electric headlight is marked 4 amperes, 2 ohms. How many cells of 2-volt storage batteries will be necessary to operate this lamp?

Answer: By Formula 2, 4 amperes multiplied by 2 ohms equals 8 volts. Therefore 8 volts divided by the voltage of a single battery, which is 2 volts, gives 4 cells as the number required.

Example: A dry battery has an electro-motive force or voltage of 1.5 volts, and an internal resistance of one-eighth of an ohm. What is its maximum current capacity?

Answer: By Formula 3, 1.5 volts divided by 0.125 ohms equals 12 amperes as the maximum current capacity of the battery.

Electricity, Forms of. Electricity or electrical energy may be generated in several ways—mechanically, chemically and statically or by friction. By whatever means it is produced, there are many properties which are common to all. There are also distinctive properties. The current supplied by a storage battery will flow continuously until the battery is practically exhausted, while the current from a dry battery can only be used intermittently: that is, it must have slight periods of rest, no matter how short they may be.

The dynamo or magneto current is primarily of an alternating nature or one which reverses its direction of flow rapidly. In use, this alternating current is changed into a direct or continuous current flowing in one direction only, by means of a commutator. Any of the forms described are capable of igniting an explosive charge in a motor cylinder, but the static or frictional form of electricity is not used for this purpose on account of its erratic nature.

Electric Lamps. It is well to remember that electric lamps consume a great deal of power. One 16 candlepower lamp requires about one-twelfth of a horsepower to operate it. The electrical energy required per candlepower is a trifle over 4 watts. A 4-volt, 4 candlepower lamp would require a storage battery of 24 ampere-hour capacity to enable the lamp to burn 6 hours. The same battery would run a 4-volt, 1 candlepower lamp 24 hours.

Electric Motors. A well designed electric motor for use in connection with a storage battery for automobile propulsion must be capable of withstanding an overload of over 100 per cent for at least thirty minutes at a time, or for even a longer period, without unduly overheating. The motors used on electric automobiles are usually series-wound, as this type of winding has been found to give the most satisfactory results in general use.

There are three types of electric motors in general use, these are:

Shunt-wound motors, in which the field-magnets are wound with a great many turns of very small wire, the ends of which are directly connected to the terminals of the commutator brushes.

Series-wound motors, which have the field-magnets wound with a few turns of very large wire. One end of this wire is connected to one commutator brush terminal. The other end of the wire on the field-coils and the other brush terminal being connected with a battery or other source of current.

Compound-wound motors are a combination of the above motors, having the field-magnets double-wound, that is with both shunt and series-windings.

The armature of an electric motor is built up of a number of disks of sheet iron, which are separated from each other by a suitable coating of varnish or by the use of thin sheets of paper between the disks, this is to prevent what are known as eddy currents, which are a source of constant trouble if not eliminated.

The function of the commutator of an electric motor is to receive the current from the battery or other source of power, by means of the brushes, and transmit it to the windings or coils upon the periphery of the armature.

The essential features of an electric motor are as follows:

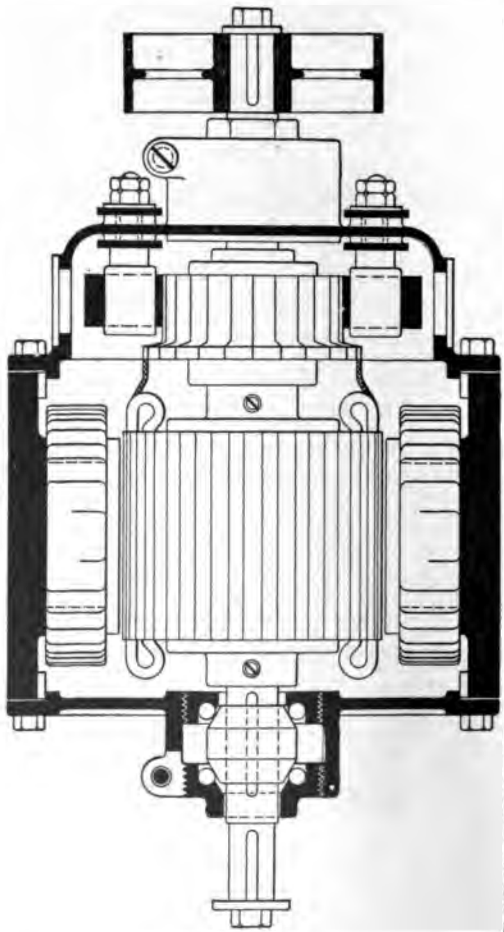
The brushes, which are located upon and around the periphery of the commutator and serve to transmit the current to the commutator from the outside source or supply.

The commutator or current distributer and laminated wrought iron armature.

The field-magnets and pole-pieces; the latter are usually an extension of the magnet core.

The magnet frame, usually of cast steel.

Figure 47 shows a form of series-wound electric motor of the style most commonly used for automobile work. The motor is of the four-pole type, having its field-coils arranged at equidistant points around the periphery or circumference of the armature. The armature shaft is carried by ball-bearings, with suitable screw and clamp adjustment as shown. The armature is of the slot-wound type and has a commutator with self-adjusting carbon brushes. The left-hand extension of the armature shaft is fitted with a key and washer for the driving gear or sprocket, while the right-hand end has a pulley or brake wheel to use for stopping the car under ordinary conditions of travel. The magnet frame is of cast steel and the magnet cores and armature disks of laminated wrought iron. The field-coils are machine-wound and the armature coils form-wound, while both are thoroughly taped and



ELECTRIC MOTOR

FIG. 47

waterproofed. The commutator generally has the same number of sections as the armature has slots and is usually of large diameter and wide contact face.

Electric Motor Troubles. Electric motor troubles may be classed as follows: Open-circuits, improper connections and short-circuits.

An **Open-circuit** may be found at any one of the following places:

Battery terminals. These may be badly corroded or worked loose, so as to form a poor or improper electrical contact.

Controller. A connection may have worked loose, or the spring contact-fingers are not making good contacts.

The removable plug may be out or not making a proper contact.

Brushes. One of the carbon brushes of the motor may have fallen out, or the brush springs may be too weak to insure a good contact.

The reversing switch may be halfway over, thus leaving the batteries and motor on an open circuit.

All points of contact, such as terminals or binding-posts, brush-holders, switches and controller spring contact-fingers, should be bright and clean so as to give a perfect metal-to-metal contact.

The fact that the car will not start and the ammeter shows no current indication is generally a sign of **Improper battery connections.**

When the different trays of the battery are not properly connected together, short-circuits will occur between these sections and run down or exhaust the batteries in a very short time. All battery terminals should be plainly marked so that it is impossible to make wrong connections. If the trouble above stated occurs the battery trays must be wrongly connected amongst themselves.

If the ammeter indicates a large current and the motor refuses to turn, the trouble is what is known as a **Short-circuit**, or a path for the current outside of the motor.

Lift one of the commutator brushes and if the amperage shown by the ammeter drops, or perhaps disappears altogether, one of the field-coils is short-circuited or there is a broken wire touching some part of the metal of the car or an exposed portion of another wire.

Electric Motors, Speed-Regulation of. The speed and consequently the power of an electric motor may be varied in three ways, as follows:

First, by introducing variable resistances in the motor and battery circuit.

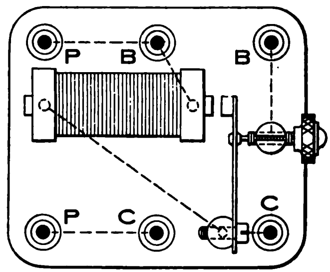
Second, by varying the voltage of the batteries by different combination of the battery trays.

Thirdly, by connecting the field-coils of the motor, all in series, in series-parallel and all in parallel. Various other combinations of the above named methods may also be had.

Electro-magnetic Vibrator, Independent Form of. Gasoline motors with high compression and speed require a jump-spark of greater intensity and volume than those with less compression and speed, to properly ignite the charge. They consequently require a battery of higher voltage and greater current volume to induce a greater flow of the magnetic flux or lines of force in the iron core of the coil. This has the effect of reducing the number of vibrations per minute of the trembler attached to the coil. Numerous tests have shown that when the motor to which such a coil is attached attains a certain rate of speed, the vibrator refuses to work when the circuit is closed by the commutator on the motor. That is due to the fact that the period of time during which the electrical circuit is closed and opened by the commutator is not of sufficient duration to allow the vibrator to properly perform its function. It is to overcome these objections that the electro-magnetic vibrator, here illustrated and described, is intended.

Figure 43 is a plan or top view, clearly showing the wiring and connections to the terminals or binding-posts. This is also an important point in the construction and enables the operator to connect the vibrator to the coil, battery and motor without any chart or previous instructions, and if properly connected as marked, no ground or short-circuit can occur. P and P are the con-

nections to the primary winding of the induction coil: B and B, the battery connections, and C and C the connections to the commutator on the motor. The wiring shown by the dotted lines between the terminals P and B, and also between P and C, are merely blind or dummy wires, so as to prevent any mistakes in the wiring of the car, as all connections between the battery, coil and motor must be made through the vibrator. As this electro-magnetic vibrator is not connected in series with the battery and coil current, but is in a simple shunt from the battery, it utilizes only a fraction of the battery current, while the remainder of the current goes directly to the primary winding of the coil, and the current used by the coil is at all times controlled by the operation of the vibrator.



VIBRATOR FIG. 48

The trouble experienced by owners of cars having multi-cylinder motors equipped with the ordinary vibrator or trembler form of jump-spark ignition indicates that something more reliable, more nearly fool proof, and therefore better

adapted to the requirements of the automobile maker and user, is required. The use of this device insures the absolute synchronization or timing of the spark in multi-cylinder motors with any number of cylinders.

Electro-motive Force, Definition of. The cause of a manifestation of energy is force; if it be electric energy in current form it is called **Electro-motive force.** An electro-motive force or pressure of **One Volt** will force **One Ampere** through **One Ohm** of resistance.

English and French Units—See Table No. 15.

Exhaust, Cause of Smoky. Smoke coming from the exhaust of a gasoline motor is due to one of two conditions: Over-lubrication—too much lubricating oil being fed to the cylinder of the motor—or too rich a mixture, that is, too much gasoline and an insufficient supply of air.

The first condition may be readily detected by the smell of burned oil and a yellowish smoke. The second, by a dense white smoke accompanied by a pungent odor.

Exhaust-valves, Diameter and Lift of. The formulas and Table No. 1, given for admission-valves, apply also to exhaust-valves. For motors with excessively high speed, the valve diameter given by the formula or table should be increased at least 15 per cent, the formula will then read,

$$D=\frac{B\times S\times R}{13,000}$$

where D is the required diameter of the valve opening, B the bore of the cylinder, S the stroke of the piston and R the number of revolutions per minute of the motor—see Admission-valves, Diameter and Lift of, also Valves.

Explosive Motors, Cycles of. Why two-cycle and four-cycle as applied to a motor? Why not one-cycle and two-cycle as used in England? The questions are by no means new, but are none the less pertinent for that. In the automobile business, where many people of comparatively little learning in mechanical matters have to deal with terms which, until now, have been strange to them, it is desirable that the language used be as nearly descriptive as possible. The terms quoted are ambiguous, to say the least. Why they are used is inexplicable. According to the best encyclopedic authorities a cycle may be defined as a series of events or happenings which recur in regular succession at stated periods of time. In so-called two or four-cycle motors the operation, during each successive stroke of the piston, is not completed within itself, but is dependent on one or more conjunctive strokes to complete the event or happening or, in other words, the cycle of events. It is impossible, therefore, to describe the movement of the piston, backward or forward, as a cycle. In the one case it is only half a cycle and in the other a quarter and hence it is not entitled to the dignity

commonly but erroneously applied to it. It would be more nearly correct to indicate the type of motor by the number of revolutions of the crank shaft and flywheel as, for example, one-revolution motor or two-revolution motor. This might, for convenience, be changed to one and two-cycle motor as stated.

Explosive Motors, Types and Forms of. When explosive motors were first introduced the use of gasoline in connection with them had not been considered as a possibility. In later years, however, coal gas has been largely superseded by gasoline vapor, and gasoline motors are to-day far more common than gas motors. The principle of operation of the two are identical, however, and it should be understood that while gasoline motors are referred to, the description applies equally to gas motors.

In 1838 the first two-cycle gas motor was patented in England by William Barnett.

In 1862 Beau de Rochas formulated the cycle of operation of an explosive motor, as afterward built by Professor Otto, commonly known as the Otto four-cycle motor.

In 1876 the first practical working motor was introduced by Crossley Bros., of Manchester, England, under the patents of Professor Otto.

Explosive motors are of three forms, known as stationary, marine and automobile. Their general

characteristics are implied by their various designations. The stationary motor may be either vertical or horizontal. Marine motors, designed for application to boats, are almost invariably vertical. Automobile motors are of comparatively recent introduction and of great variety, the aim of the designers being to secure the maximum of power and minimum of weight. They also may be vertical or horizontal.

These three forms may be again divided into two-cycle and four-cycle types. In the former an explosion occurs at every revolution. In the latter there is an explosion at every alternate revolution—see Explosive Motors, Operation of.

Explosive Motors, Operation of. Explosive motors are dependent for successful operation on two things: First, a charge of gas or vapor, mixed with sufficient air to produce an explosive mixture, which is to the motor what air is to the lungs of a human being, and second, a method of firing the charge after it has been taken into the combustion chamber of the motor.

When coal gas is used the supply is taken from the main and mixed directly with the necessary proportion of air. When gasoline is used, air is mixed with it in the correct proporton by carbureting devices.

After the charge of gas and air has been taken into the cylinder it is compressed, as will be

shown later, by the action of the motor itself and then fired, usually by an electric spark actuated by the motor, but sometimes by the use of a tube screwed into the cylinder and heated from the outside, the heat, of course, being communicated to the gas. The resulting explosion operates the motor.

The principal parts of a four-cycle explosive motor are the cylinder, the piston, the piston rings which fit into grooves in the piston: two sets of valves, one to admit the charge and the other to permit it to escape after the explosion: a crank shaft and connecting rod which connect it with the piston head and a flywheel, whose presence insures steady running of the motor, and whose further functions will be better understood as the description proceeds. In the two-cycle form of motor there is really but one valve, the exhaust and admission-ports being covered and uncovered by the piston itself.

All of the parts referred to are of the motor proper. Other parts, which are separate from the motor but on which its operation depends, are the carbureter, which supplies the charge of gasoline vapor and air for a gasoline motor, or a mixing chamber for mixing air and gas in the case of a gas motor, and the batteries and other parts of the electrical ignition device.

A part which has no connection with the actual running of the motor but with which practically

all are fitted is the muffler, whose purpose is to deaden the sound of the explosion.

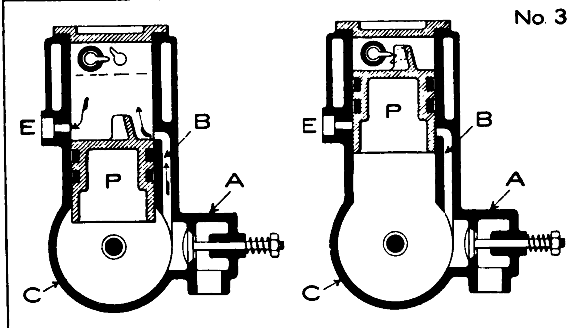
The cylinders of all except very small motors are as a rule partly encased in a chamber through which water is circulated, the object of this being to keep the cylinder cool.

TWO-CYCLE MOTOR. The foregoing outline of the functions of the parts of the motor prepares us for a description of the two-cycle form of motor. This particular form of motor draws in a charge of gas or vapor, compresses it, fires it and discharges the product of combustion or burned gases while the crank makes but a single revolution and while the piston makes one complete travel backward and forward.

Diagram No. 3 shows two sectional views—that is to say, views of the motor cut in two, longitudinally—of the principal parts of a two-cycle motor. Other parts, such as the crank shaft, connecting rod and flywheel, are omitted to avoid confusion. C is the crank case and A the admission valve, through which the vapor passes to the crank case. B is the inlet passage, through which it passes from the crank chamber to the cylinder. P is the piston. The igniter, which makes the electric spark when the lower point comes in contact with the upper, is shown immediately below the cylinder cover. This causes the explosion of the vapor. E is the exhaust port, through which the burned charge

escapes after the piston has been driven outward by the explosion and has reached the end of its stroke.

Let it be supposed that the motor is still and the crank chamber C is full of gas or vapor. To start the motor the piston is started by means of a crank on the flywheel shaft, and as it passes



TWO-CYCLE MOTOR DIAGRAM

to the position shown in the left-hand drawing it forces the charge of vapor through the port B into the cylinder. The piston then returns to the position shown in the right-hand view, moving away from the crank chamber C, and in doing so closes the port B and the exhaust opening E and compresses the charge of vapor. The points of the igniter come together, a spark occurs and the resulting explosion forces the piston outward again. When the piston reaches a point near

the end of the stroke, as shown in the left-hand drawing, it uncovers the port E and the burned charge passes out, the new charge coming through the port B immediately afterwards.

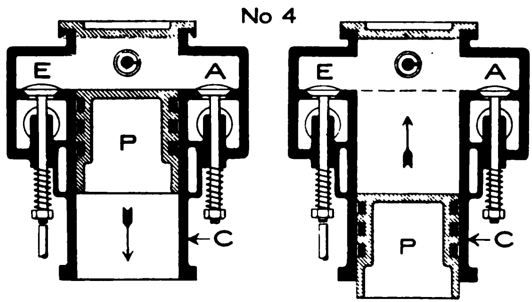
The admission of the new charge to the crank chamber is controlled by the action of the piston. As the latter travels outward it has a tendency to create a vacuum in the crank chamber. This draws the valve inward and admits the charge of vapor.

It will be observed that there is a projection on the head of the piston. This is generally known as a baffle-plate. Its object is to prevent the incoming charge from passing directly across the cylinder and out at the exhaust port E, which, it will be observed, is directly opposite it. The baffle-plate directs the incoming charge toward the combustion chamber end of the cylinder, providing, as nearly as may be, a pure charge of vapor and assisting in the expulsion of the remainder of the burned gases remaining in the cylinder as a result of the last explosion.

FOUR-CYCLE MOTOR. Diagram No. 4 furnishes two views of a four-cycle type of motor with some of the parts removed, as in Diagram No. 30. It shows a cylinder C, admission-valve A, a piston P, and exhaust-valve E in place of the exhaust-port E in Diagram No. 3.

The left-hand view shows the piston P about to suck in a charge of vapor, by the same method as

previously described, through the admission-valve A into the cylinder C. The suction continues until the piston P reaches the position shown in the right-hand view. Then the piston returns until it again arrives at the position shown in the left-hand view, compressing the charge of mixture



FOUR-CYCLE MOTOR DIAGRAM

during this operation. Just before the piston arrives at the end of its travel in this direction, the charge of vapor, now under compression, is ignited by the method previously explained and its expansion forces the piston back to the position shown in the right-hand view. When the piston has, for the second time, reached the position shown in the right-hand drawing, a mechanical device opens the exhaust-valve. The exhaust-valve remains open until the piston has again arrived at the position in the left-hand view. Then it closes, the piston again commences to

draw in a charge of vapor and the cycle of operation of the motor is repeated.

Fiber, Vulcanized. Paper-pulp treated with sulphuric acid, washed and afterwards compressed into sheet or rod form, is known as vulcanized fiber.

Field Coil—See Electric Motors.

Flexible-coupling—See Compensating Joints, also Universal Joints.

Fluxes for Soldering. Some good fluxes for soldering purposes are:

Iron or steel....	Borax or sal-ammoniac.
Tinned iron.....	Resin or chloride of zinc.
Copper to iron..	Resin.
Iron to zinc.....	Chloride of zinc.*
Galvanized iron.	Mutton tallow or resin.
Copper or brass.	Sal-ammoniac or chloride of zinc.
Lead	Mutton tallow.
Block tin	Resin or sweet oil.

Flywheels. One of the first and most important considerations in connection with the construction of a gasoline automobile motor is the proper diameter and weight of the flywheel. If the diameter and weight of the flywheel be known, the speed of the motor or its degree of compression will become a variable quantity. On the other hand, if the speed of the motor and the degree of compression be fixed, the diameter or weight of the flywheel rim must be varied to suit the other conditions. If the speed of the

*Chloride of zinc is simply zinc dissolved in hydrochloric (muriatic) acid, until the acid is cut or killed.

motor and its degree of compression be known, the diameter of the flywheel or the weight of the flywheel rim may be readily ascertained from the following formulas.

Weight of Rims of Flywheels. The weight of the rim of the flywheel is the only portion which enters into the following calculations, the weight of the web or spokes and hub being neglected.

Let M.P be the mean pressure of the compression, and A the area of the cylinder in square inches. If S be the stroke of the piston in inches, and N the number of revolutions per minute of the motor, let D be the outside diameter of the flywheel in inches and W its required weight in pounds, then

$$W = \frac{M.P \times A \times S \times N}{2560 \times D}$$

Diameter of Rims of Flywheels. A motor that is intended to operate at a slow rate of speed and consequently with a high degree of compression, will require a flywheel of much greater diameter and weight than a high speed motor of the same bore and stroke. It may be well to remember that within certain limitations the diameter and weight of a flywheel should be as small as is possible, as an increase in either means a reduction in motor speed and a consequent loss of power.

To ascertain the diameter of a flywheel when

all other conditions are known, if D be the required diameter of the flywheel in inches, then

$$D = \frac{M.P \times A \times S \times N}{2560 \times W}$$

Weight of Rims of Flywheels with a Given Fluctuation in Speed. If it be desired to run a motor at a practically uniform speed and with only a slight fluctuation or variation in the velocity of the flywheel, if W be the required weight of the flywheel and **x** be the allowable fluctuation of the flywheel in revolutions per minute above and below its normal speed, then

$$W = \frac{M.P \times A \times S \times N}{365 \times x}$$

Horsepower Stored in Rims of Flywheels. It is sometimes desirable to know the amount of energy or horsepower which may be stored in the rim of a flywheel of known diameter and weight, with a given speed. If H.P be the horsepower stored in the rim of the flywheel, then

$$H.P = \frac{D^2 \times W \times N}{792{,}000}$$

Safe Speed for Rims of Flywheels. The safe velocity for the rim of a cast iron wheel is taken at 80 feet per second. Let N be safe speed of the flywheel in revolutions per minute, then

$$N = \frac{18{,}335}{D}$$

The mean pressures corresponding to varying degrees of compression may be found by reference to Table No. 2—see Air, Properties of Compressed.

M.P = Mean pressure.

A = Area of cylinder in square inches.

S = Stroke of piston in inches.

N = Number of revolutions per minute.

D = Diameter of flywheel in inches.

W = Weight of flywheel in pounds.

Balancing with the Reciprocating Parts of the Motor. The flywheel should be balanced as accurately as is possible before mounting on the crank shaft. In the first place set the crank shaft on two perfectly straight parallel bars, one bar under each end. Then attach the connecting rod and piston to the crank and turn the shaft until the crank jaws are parallel with the floor or in other words at right angles to a perpendicular line drawn through the center of the shaft. Place a scale under the crank pin or use a hanging scale attached to some rigid support above the pin and connect it to the crank pin by a wire or cord sufficiently strong to carry the weight. Then find the weight of the parts according to the scale and attach the same amount to the flywheel at the same distance from the shaft on the side opposite the crank, and the result will be a fairly balanced motor. It is impossible to obtain a perfect balance, but the

above method will assist greatly in reducing the vibration of the motor.

Four-cycle Motor, Operation of. A four-cycle motor has only one working stroke or impulse for each two revolutions. During these two revolutions which complete the cycle of the motor, six operations are performed:

1. Admission of an explosive charge of gas or gasoline vapor and air to the motor-cylinder.

2. Compression of the explosive charge.

3. Ignition of the compressed charge by a hot tube or an electric spark.

4. Explosion or extremely sudden rise in the pressure of the compressed charge, from the increase in temperature after ignition.

5. Expansion of the burning charge during the working stroke of the motor-piston.

6. Exhaust or expulsion of the burned gases from the motor-cylinder.

As pressure increases with a rise in temperature, which in a motor the moment after ignition has taken place is about 2,700 degrees Fahrenheit, the higher the temperature of the ignited gases, the greater would be the pressure. As this pressure is expended in work on the motor-piston, the whole of it might, if expansion of the burning gases were continued long enough, be utilized. Full utilization of the expansion of the gases is impossible from a mechanical point of view. The expansion of the gases should be as rapid as

possible, as the faster the piston uncovers the cylinder wall, the less time will be left for the transmission of heat or energy to the cylinder wall. Gasoline vapor or gas in themselves are not combustible, but must be mixed with a certain amount of air before ignition and consequent combustion can be effected. The combustion of the gases is not instantaneous, but continues during the entire working stroke of the motor-piston. The extremely high temperature produced by the combustion necessitates the use of cooling devices round the exterior of the motor cylinder, such as air-cooling ribs or a water-jacket—see also Explosive Motors.

Fractions of an Inch, Decimal—See Table No. 10.

Frames—See Chassis, also Running Gears.

Frame-hangers—See Body-hangers.

French and English Units—See Kilogram, Kilometer, Liter—Table No. 15.

Friction Clutches—See Power Transmission Devices.

Friction Drive, Forms of Disk and Roller. Since the inception of power-driven machinery, one of the principal requirements has been some form of speed-changing device to suit the varying conditions of the work. Devices for this purpose are of such innumerable forms and types that it would not be within the scope of this work to discuss them.

The oldest form of speed-changing device in use consists of two sets of pulleys of different diameters on parallel shafts, driven by an endless belt. Change of speed is effected by shifting the belt from one set of pulleys to another. Another method is by two sets of gears, arranged so that the required pair of gears can be either slid into mesh, or be brought together by means of an eccentric. Taper pulleys in the form of truncated cones with their unlike ends adjacent on parallel shafts and belt driven, form a third means of variable speed transmission, the change being effected by sliding the belt along the surface of the cones while they are in motion.

In the disk and roller transmission, a roller engages the flat surface of a disk, and transmits power by pressure being brought to bear upon the contact surfaces. The speed is increased or decreased by sliding the roller along the face of the disk between the center and the edge. By moving the roller to the right or left of the center of the disk, the direction of motion of the roller or the disk may be changed at will. If the disk be the driver the direction of rotation of the roller will be changed, and if the roller is driving the direction of the rotation of the disk will be changed, when the roller passes from one side of the center of the disk to the other.

The first two forms mentioned, the sets of pulleys or gears, are only capable of changes of

speed in fixed ratios as 1-2-3 or 1-3-9, etc., while the third, the twin taper pulley or cone form, will give a gradual variation of speed, with the normal driving speed at a halfway point in their length if they are of similar dimensions throughout. The disk and roller form of speed-change transmission is not only capable of giving a gradual increase or decrease of speed, but, as before stated, by sliding the roller from one side of the center of the disk to the other, a change in the direction of rotation of either roller or disk may be effected.

But the disk and roller form of variable speed transmission has an objection in the fact that the portion of the face of the disk which is in contact with the roller does not travel at a uniform rate of speed throughout the length of the roller contact. Suppose the roller were made in three separate sections, with only line contacts or knife edges, one inch apart, and that the radius of travel of the center section of the roller from the center of the disk was four inches, and for the inner and outer sections, 3 and 5 inches respectively. The travel of the center section of the roller on the surface of the disk for one revolution would be 25.13 inches, for the outer section 31.42 inches, and for the inner section 18.85 inches. This plainly shows that slippage must take place during the transmission of power by means of the disk and roller method.

In spite of this fact and on account of its simplicity of construction the disk and roller form of variable speed transmission is in use for a great many different purposes in the mechanical arts. Examples are small drill presses, grinding machines and countershafts. In automobile use it forms an ideal method of transmission with variable speed and reverse or change of direction, without gears or belts.

While there are a great many combinations and adaptations of the disk and roller form of variable speed power transmission in use, they are all based on the three elementary forms of construction shown in the accompanying drawings.

The upper view in Figure 49 shows one form of disk and roller transmission, in which the disk forms an integral part of the motor flywheel, and the power is transmitted to the driving wheels of the vehicle by suitable means from the roller shaft. As the power to be transmitted by the device is at all times proportional to the velocity, in feet per minute, of the path of travel of the roller on the disk, and to the pressure at the contact between the disk and roller, it follows that the nearer the center of the disk the roller travels, the less its velocity, and the greater the pressure required between the disk and roller to transmit the same power. In this type the disk velocity is uniform and the roller speed variable.

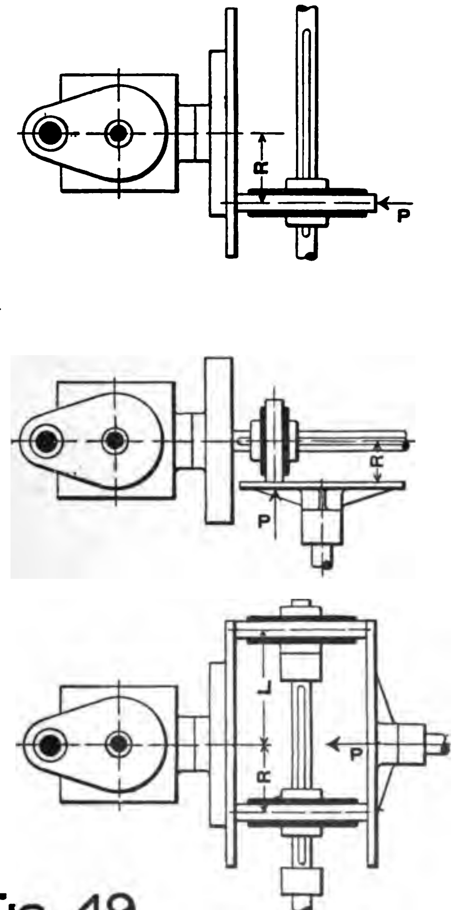


FIG. 49

The center view is another form of disk and roller transmission, in which the roller is slidably located upon the motor shaft, and the power transmitted to the driving wheels of the vehicle, through the medium of a countershaft carrying the disk. With this arrangement, as the roller speed is constant, the speed of rotation of the disk will vary, as the roller is moved from the center to the periphery of the disk. The same pressure is required to transmit the same power when the roller is at the periphery of the disk, and the disk shaft at its slowest speed, as when the roller is near the center of the disk, and the disk shaft at its highest speed.

Another form of disk and roller transmission, in which two rollers and disks are employed, is shown in the lower view. One roller and disk run loose. By this method twice the power can be transmitted as in the case of the constructions previously illustrated. Double the pressure must, of course, be put upon the loose disk to effect this increase of power. When both rollers are at the periphery of the driving disk on the motor flywheel, the pressure upon both rollers is alike, as the idle roller transmits its portion of the power through the idler disk back to the sliding roller, thus giving twice the traction of the single roller device. When the sliding roller is moved toward the center of the disks, the pressure from the idler disk is increased upon the sliding roller

and consequently decreased upon the idle roller, thus giving a greater tractive effort than if the idle roller were not used. While slightly more complicated, the advantage of this construction over the other forms is obvious. While the pressure upon the idler disk is doubled, the pressure upon the contact surface of the driving roller is the same as if only one roller were used and but half the power transmitted.

The following formulas deduced from the results of tests give the power which can be transmitted by the constructions shown in Figure 49.

Let P be the pressure in pounds between the contact surfaces of the disk and roller, F the width of the face of the roller, C the coefficient of adhesion or tractive effort between the contact surfaces, N the speed in revolutions per minute, R and L the radii as shown in the drawings, and H.P the horsepower transmitted by the disk and roller. Then

$$\text{H.P} = \frac{P \times F \times C \times N \times R}{21{,}000} \text{ (Nos. 1 and 2)}$$

$$\text{H.P} = \frac{P \times F \times C \times N \times R \times L}{63{,}000 \times (R + L)} \text{ (No. 3)}$$

The values of C for different materials are given as follows:

0.15	Cast Iron and Cast Iron.
0.18	Cast Iron and Copper.
0.25	Cast Iron and Rawhide.
0.27	Copper and Rawhide.
0.30	Rawhide and Rawhide.

Example: What will be the maximum and minimum horsepower transmitted by a disk and roller of the form illustrated in the upper view in Figure 49, with copper-faced disk and cast iron roller of 1 inch face? The contact circles on the disk are 3 and 7½ inches respectively, and the motor speed is 900 revolutions per minute, with 100 pounds pressure at the contact surfaces.

Answer: As the coefficient of traction for cast iron and copper is 0.18, then the minimum will be: $100 \times 1 \times 0.18 \times 900 \times 3$, or 48,600, divided by 21,000, which gives 2.31 horsepower. The maximum will be $100 \times 1 \times 0.18 \times 900 \times 7.5$, which equals 121,500, divided by 21,000, giving 5.78 horsepower.

Example: Under the same conditions with a roller 6 inches in diameter, what horsepower will the form of transmission illustrated in the center view in Figure 49 transmit for minimum and maximum disk speeds?

Answer: As the speed of the roller is constant and the disk speed varies as the roller is moved in or out from the center, the power transmitted will be constant at any portion of the surface of the disk, and will be the same as the minimum power for the form illustrated in the above example, that is, 2.31 horsepower. As the leverage is increased as the roller moves out, the speed of the disk is correspondingly decreased, or vice versa.

By means of the formulas given the power transmitted by any of the three forms illustrated may be readily calculated for a given pressure, speed and width of roller contact-surface.

Front Axles—See Axles.

Fuel Economy, Effect of Motor-speed on. In a well designed gasoline motor with admission and exhaust valves of ample proportions, a practically full charge should be taken into the motor cylinder at any rate of speed and the compression will improve considerably at high speeds owing to the time for leakage between the piston-rings and cylinder wall being diminished. This gives a decided gain in fuel economy. Above a certain rate of speed, however, the compression pressure will be reduced, due to the increased friction of the gases in their passage through the carbureter, admission-pipes and valves of the motor. With increased motor speed less time is allowed for the heat developed in the charge during compression, to pass through the cylinder wall, thus increasing the temperature and consequent explosion pressure of the gases at the time of their ignition. This also improves the fuel economy of the motor.

Gases, Expansion of. All gases expand equally, $\frac{1}{273}$ part of their volume for each degree of temperature, Centigrade, or $\frac{1}{491}$ part of their volume for each degree of temperature, Fahrenheit.

Gas Lamps. The gas used in gas lamps is generated by water, in minute quantities, dropping on acetylene (carbide of calcium); the gas thus formed passes from the generating chamber into the body of the lamp and is consumed at the lava tips, which are placed in front of a highly polished mirror. The generators in some cases are separated from the lamp itself and placed on the dashboard or under the hood, a rubber hose conveying the gas to the lamp.

Gasoline Explosions. There are two entirely different kinds of explosion, which would undoubtedly both be referred to as gasoline explosions. The real gasoline explosion is the kind taking place in the cylinder of a gasoline motor, in which heat and pressure are suddenly produced by the combustion of gasoline vapor in air. The other kind of explosion referred to may be explained as follows:

If a tank of gasoline be placed on a woodpile and the latter set on fire, the heat would raise a pressure in the tank, which would rapidly increase and the tank would finally explode from the pressure. The gasoline would then be thrown in all directions, and, owing to its superheated condition, the greater part of it at least would instantly vaporize, mix with the air of the atmosphere and be ignited by the flame which caused the explosion.

Gasoline Fires, Extinguishing. A number of fires have been caused by leaky gasoline pipes on automobiles and many persons would like to know of chemicals which can be used to put out such fires. Water is an exceedingly dangerous proposition to use and it is not always possible to get at the fire to smother it with wet rags or waste.

In case of fire due to gasoline, use fine earth, flour or sand on top of the burning liquid. Never use water, it will only serve to float the gasoline and consequently spread the flames.

A dry powder can be used for this purpose which will extinguish the fire in a few seconds. It is made as follows: Common salt, 15 parts—sal-ammoniac, 15 parts—bicarbonate of soda, 20 parts. The ingredients should be thoroughly mixed together and passed through a fine mesh sieve to secure a homogeneous mixture.

If by any chance a tank of gasoline takes fire at a small outlet or leak, run to the tank and not away from it, and either blow or pat the flame out. Never put water on burning gasoline or oil, the gasoline or oil will float on top of the water and the flames spread much more rapidly. Throw fine earth, sand or flour on top of the burning liquid. Flour is best. The best extinguisher for a fire of this kind in a room that may be closed, is ammonia. Several gallons of ammonia, thrown in the room with such force as

to break the bottles which contain it, will soon smother the strongest fire if the room be kept closed.

Gasoline, How Obtained. Benzine, Gasoline, Kerosene and the kindred hydro-carbons are products of crude petroleum.

They are separated from the crude oil by a process of distillation. The process is very similar to that of generating steam from water.

Crude petroleum subjected to heat will give off in the form of vapor such products as Benzine, Gasoline and Kerosene, etc. The degrees of heat at which these products are separated are comparatively low. Various degrees of heat will separate the distinct products. As a means of illustration, it may be said that the crude oil when raised to certain temperatures gives off vapors which when cooled liquefy into what are known as Benzine, Gasoline and Kerosene.

Gasoline Motors—See Explosive Motors.

Gasoline, Not Dangerous. A lighted match placed at the opening of a new 2-gallon can of gasoline merely caused a small flame an inch long, which could be extinguished with the point of a finger.

Gasoline was poured into an open vessel and a lighted cigarette dropped into it. Result: It was at once extinguished.

A lighted cigarette was smoked vigorously from within two feet above to a quarter of an inch of

the gasoline—also all around and underneath the vessel, but no ignition occurred.

A small quantity of gasoline was poured on a cigarette while smoking—still no ignition occurred.

A can was then made hot, and the gasoline poured into it, so that it would vaporize more quickly—a lighted cigarette was then smoked into it, as in the third case, but failed to cause ignition.

Gasoline Tanks—See Tanks.

Gasoline Motor Construction. When designing a gasoline automobile motor, the first question that will arise is as to the proper number of cylinders. The question as to the proper number of cylinders for an explosive motor may be briefly summed up as follows: A single cylinder has the merit of simplicity, and requires less mechanism to operate it, but tends towards excessive vibration. Multi-cylinders develop more power with less weight and reduce the motor vibration and strain, and have also other advantages over a single cylinder. The question therefore is: How many cylinders are best in practice? To give the best results, a two-cylinder motor should, if the cranks are opposed, have its cylinders in axial alignment in order to ensure a uniform impulse. If the cranks and cylinders are opposed it is possible to obtain correct mechanical balance of connecting rods and pistons, and vibration is thus diminished. If the cylinders are of the twin form

with the cranks opposed, explosions will necessarily follow each other at a half revolution, and one and a half revolutions apart. This gives irregular impulses which tend to set up vibration. The next best construction is three cylinders, with the cylinders parallel, and the cranks set at an angle of 120 degrees. This gives regular impulses two-thirds of a revolution apart, and consequently a more uniform strain on the parts, and reduces vibration.

A four-cylinder motor has greater advantages of mechanical balance than the three-cylinder form, but on the other hand, by reason of the greater amount of exposed cylinder wall for a given capacity, it is not as economical in fuel consumption. The greater advantage of four as compared with the three cylinders, is a greater division of the impulses, reducing vibration to a minimum.

Other points to be considered in the design of a motor are:

The proper arrangement or location of all working parts so as to be readily accessible for repair or adjustment.

Practically automatic lubrication of the motor.

The best and simplest method of operating the admission and exhaust-valves.

The proper diameter and weight of flywheel and a practically correct balance of the reciprocating parts of the motor.

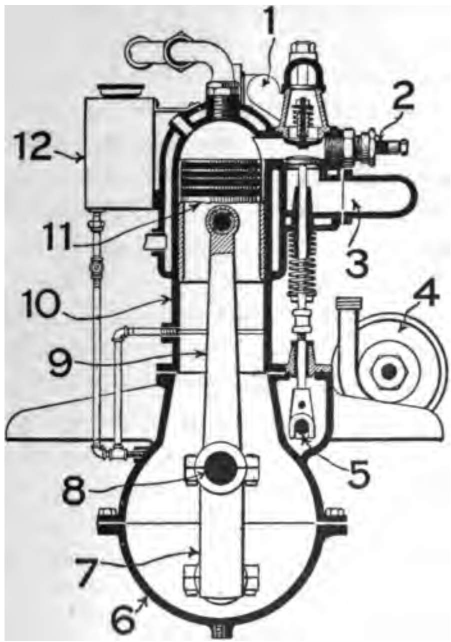


FIG. 50

VERTICAL CYLINDER, WATER-COOLED GASOLINE MOTOR.

1. **Admission valve.**
2. **Spark plug.**
3. **Exhaust valve.**
4. **Rotary pump.**
5. **Cam shaft.**
6. **Crank case.**
7. Crank shaft.
8. Crank pin.
9. Connecting rod.
10. Cylinder.
11. Piston and rings.
12. Oil tank.

The best and most reliable system of ignition, with a view to eliminating ignition troubles.

The most economical type of carbureter and one that will require the least attention.

And last, but not least, reduction of weight, simplicity of construction and good mechanical design.

In the construction of motor cylinders experience has clearly established one point—that the cylinder, with its combustion and valve-chambers, should be integral or in one piece, and that no joints closed by gaskets should exist back of the head of the piston. While all manufacturers do not adhere to this rule, it is a fact that many difficulties have been experienced with leaky joints, and that the plan of avoiding them altogether should be followed.

Figure 50 shows a vertical cross-section of a gasoline automobile motor of the most approved modern type. It has automatic lubrication, detachable inlet or admission-valve and rotary pump for the water circulating system.

Figure 51 illustrates a modern type of vertical four-cylinder gasoline automobile motor, having the admission-valves automatically throttled by means of a centrifugal governor on the end of the cam-shaft, as shown in the drawing. The admission-valves are mechanically operated.

While the cooling of the cylinder of an explosive motor is most successfully accomplished by means of a water-circulating system, a number of up-to-date cars successfully use cooling devices other than water. The success of air cooling for explosive motors is due in most cases to the use

of a number of ribs cast integral with the cylinder and having a large radiating surface.

Figure 52 shows a form of vertical air-cooled motor with radiating ribs cast around the cylinder and valve-chamber. The motor has a detachable, atmospherically operated admission-valve, without

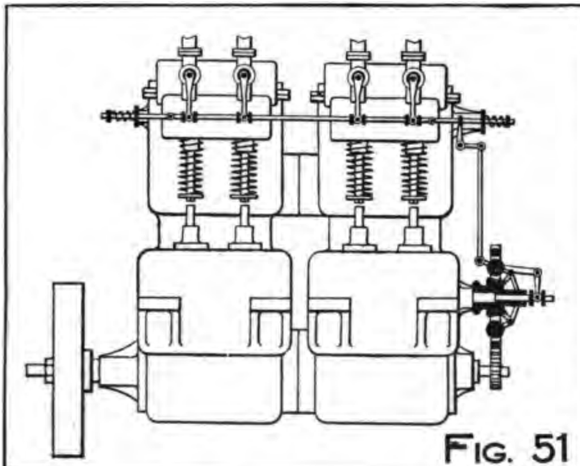


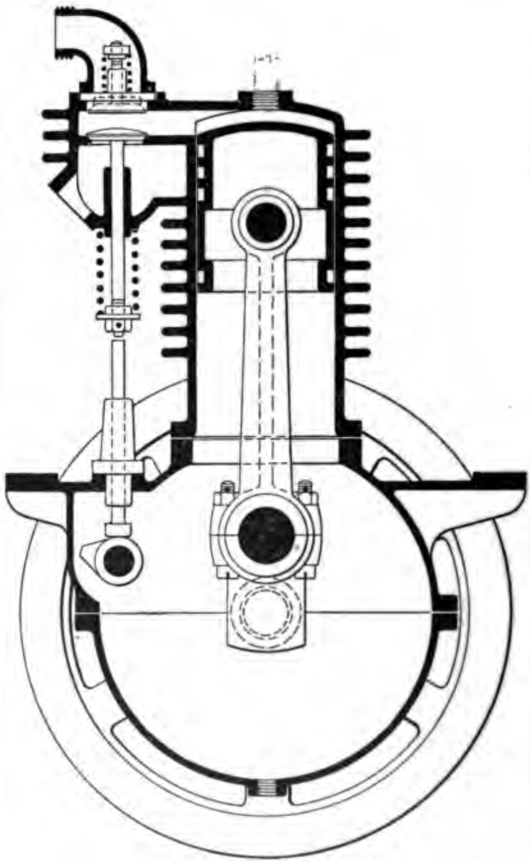
FIG. 51

VERTICAL FOUR-CYLINDER MOTOR
With mechanically operated admission-valves with automatic throttling governor.

packing. The valve and cage may be removed by simply removing two nuts—see Explosive Motors, also Four-cycle Motor.

Gasoline Motor, Fuel Consumption of. The fuel consumption of a motor is always a serious question, and one of importance to the purchaser as well as to the manufacturer.

FIG. 52



AIR-COOLED MOTOR

Ordinarily about one and two-tenths pints of gasoline per horsepower hour under full load will cover the fuel consumption. That is, when the mixture is of the proper explosive quality and the water comes from the jacket at a temperature of about 160 degrees Fahrenheit.

The temperature of the water in the jacket around the cylinder has a great deal to do with the fuel consumption.

If the water is forced around the cylinder so as to keep it cold, the heat from the combustion is cooled down so quickly by radiation that the expansive force of the burning gases is materially reduced, and consequently less power is given up by the motor.

The object of the water is not to keep the cylinder cold, but simply cool enough to prevent the lubricating oil from burning. The hotter the cylinder with effective lubrication the more power the motor will develop.

It should be remembered that a hot motor is the most economical in fuel.

Gasoline, Thermo-dynamic Properties of Gasoline and Air. The following table, No. 12, gives the thermo-dynamic properties of gasoline and air and may be of interest, in view of the fact that information on this subject is sparse and most of that only theoretical or empirical deductions.

This table gives the explosive force in pounds

per square inch of mixtures of gasoline vapor and air, varying from 1 to 13 down to 1 to 4, also the lapse of time between the point of ignition and the highest pressure in pounds per square inch attained by the expanding charge of mixture. The tests from which the results given were obtained, were made with a charge of mixture at atmospheric pressure, so as to more accurately note the results, as the mixture takes much longer after ignition to attain its highest pressure, and is slower also in expanding.

It may be well to remember that there are no more heat-units, and consequently no more foot-pounds of work in a mixture of gasoline and air, under 5 atmospheres compression, than under 1 atmosphere compression.

Flanged or ribbed air-cooled motors will approach the figures given in the table for the initial explosive force for the varying compressions, very closely, while thermal-syphon water-cooled motors will come within about 20 per cent of these results, and pump and radiating coil cooled motors will come within about 30 per cent. While it appears at the first glance that the proper thing to do to get the greatest efficiency from a motor would be to let it run as hot as possible, experience has shown that the repair bill of a hot motor will more than offset its efficiency over the cooler water-jacketed motor, with pump and radiating coils. The last two columns in the table give

the temperature of the burning gases, the first of the two columns the actual temperature with the accompanying mixture of gasoline and air, and the second the theoretical temperatures, or temperature to which the burning mixture should attain, if there were no heat losses.

TABLE NO. 12.

THERMO-DYNAMIC PROPERTIES OF GASOLINE AND AIR.

Gasoline, Vapor and Air.	Time in Seconds between Ignition and Highest Pressure.*	Explosive Force in Pounds per sq. in. Compression in Atmospheres.			Temperature of Combustion in Degrees Fahrenheit.*	
		3	4	5	Actual.	Theoretical.
1 to 13	0.28	156	208	260	1857	3542
1 to 11	0.18	183	244	305	2196	4010
1 to 9	0.13	234	312	390	2803	4806
1 to 7	0.07	261	348	435	3119	6001
1 to 5	0.05	270	360	450	3226	6854
1 to 4	0.07	240	320	400	2965	5517

* At atmospheric pressure.

Gear, Change-speed—See Power Transmission Devices.

Gears, Diametral Pitch System of. Table No. 13 gives the necessary dimensions for laying out and cutting involute tooth spur gears from No. 16 to No. 1 diametral pitch. Formulas are also given so that if the number of teeth and the diametral pitch are known, the pitch diameter can be ascertained—also, the diametral pitch,

outside diameter, number of teeth, working depth, and clearance at bottom of tooth:

P = Pitch diameter in inches.
D = Diametral pitch.
W = Working depth of tooth in inches.
T = Thickness of tooth in inches.
O = Outside diameter in inches.
C = Circular pitch in inches.

(1) $$\text{Pitch diameter} = \frac{T}{D}$$

(2) $$\text{Outside diameter} = P + \frac{2}{D}$$

(3) $$\text{Diametral pitch} = \frac{T}{P}$$

(4) $$\text{Circular pitch} = \frac{3.142}{D}$$

(5) $$\text{Working depth of tooth} = \frac{2}{D} = 2 \div D$$

(6) $$\text{Number of teeth} = P \times D$$

(7) $$\text{Thickness of tooth} = 1.571 \times D$$

(8) $$\text{Clearance at bottom of tooth} = \frac{C}{20}$$

For example: Required, the pitch diameter of a gear with 20 teeth and No. 5 diametral pitch. From Formula No. 1, as the pitch diameter is equal to the number of teeth divided by the diametral pitch, then 20 divided by 5 equals 4, as the required pitch diameter in inches.

What is the outside diameter of the same gear?

From Formula No. 2, as the pitch diameter is 4 inches, and the diametral pitch No. 5, then 4 plus $\frac{2}{5}$ equals $4\frac{2}{5}$ as the proper outside diameter for the gear.

What would be the diametral pitch of a gear with 30 teeth and 5 inches pitch diameter? From Formula No. 3, 30 divided by 5 equals 6, as the diametral pitch to be used for the gear. In this manner by the use of the proper formula any desired dimension may be obtained.

Table No. 13.

Dimensions of Involute Tooth Spur Gears.

Diametral Pitch.	Circular Pitch.	Width of Tooth on Pitch Line.	Working Depth of Tooth.	Actual Depth of Tooth.	Clearance at Bottom of Tooth.
1	3.142	1.571	2.000	2.157	0.157
2	1.571	0.785	1.000	1.078	0.078
3	1.047	0.524	0.667	0.719	0.052
4	0.785	0.393	0.500	0.539	0.039
5	0.628	0.314	0.400	0.431	0.031
6	0.524	0.262	0.333	0.360	0.026
7	0.447	0.224	0.286	0.308	0.022
8	0.393	0.196	0.250	0.270	0.019
10	0.314	0.157	0.200	0.216	0.016
12	0.262	0.131	0.167	0.180	0.013
14	0.224	0.112	0.143	0.154	0.011
16	0.196	0.098	0.125	0.135	0.009

Gear, Differential—See Power Transmission Devices.

Gears, Horsepower Transmitted by. The following formulas will give the horsepower that

may be transmitted by gears with cut teeth of involute form and of various metals.

H.P = Horsepower.

P = Pitch diameter in inches.

C = Circular pitch in inches.*

F = Width of face in inches.

R = Revolutions per minute.

$$H.P = \frac{P \times C \times F \times R}{90} \quad \text{(Annealed tool steel.)} \quad (1)$$

$$H.P = \frac{P \times C \times F \times R}{140} \quad \text{(Mach. steel or Phosphor Bronze.)} \quad (2)$$

$$H.P = \frac{P \times C \times F \times R}{410} \quad \text{(Cast Brass.)} \quad (3)$$

$$H.P = \frac{P \times C \times F \times R}{550} \quad \text{(Cast Iron.)} \quad (4)$$

Example: Required, the horsepower which a tool steel pinion, 2 inches pitch diameter, 1 inch face and No. 10 diametral pitch, will transmit at 900 revolutions per minute.

Answer: From the table the circular pitch corresponding to No. 10 diametral pitch is 0.314. Then by Formula No. 1, $2 \times 0.314 \times 1 \times 900$ equals 565.2. This, divided by 90, gives 5.29 horsepower.

---

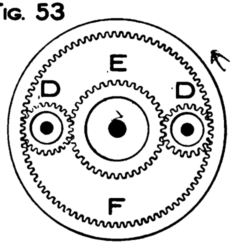
*The circular pitch corresponding to any diametral pitch number, may be found by dividing the constant 3.1416 by the diametral pitch.

Example: What is the circular pitch in inches corresponding to No. 6 diametral pitch?

Answer: The result of dividing 3.1416 by 6 gives 0.524 inches as the required circular pitch.

Gear, Internal-epicyclic. It is often desired to ascertain the speed of rotation of the different members of this form of gearing. To calculate their speeds, the following formulas are given, which, by reference to the letters designating the different parts in Figure 53, may be readily solved.

FIG. 53



INTERNAL GEAR

Let R be the revolutions per minute of the disk or spider carrying the pinions D.

Let N be revolutions per minute of the gear E.

Let G be the revolutions per minute of the internal gear F.

When the internal gear F is locked and gear E rotating, the speed in revolutions per minute of the disk or spider carrying the pinions D is

$$R=N\left(\frac{E}{E+F}\right)$$

If the internal gear be locked and the spider carrying the pinions D be rotated, then the speed in revolutions per minute for the gear E will be

$$N=R\left(\frac{E+F}{E}\right)$$

If the spider carrying the pinions D be held rigid and the gear E be rotated, the speed in

revolutions per minute for the internal gear F is

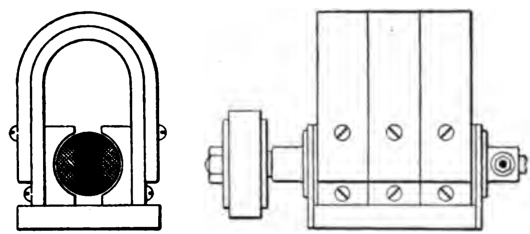
$$G=\frac{N\times E}{F}$$

If the pitch diameter of the gears is not readily obtainable, the number of teeth in each gear may be used instead, as the result will be exactly the same.

Generator. This term is usually applied to any form of chemical or mechanical energy which can be used to produce a current of electricity. Mechanical generators of electricity used for ignition purposes are of two forms, dynamos or magnetos. The former is self-exciting by means of coils of wire wound upon the magnet limbs. The latter has permanent magnets instead of coils of wire to induce the current in the armature of the magneto. Magnetos, on account of their simplicity of construction and low first cost, are more generally used for ignition purposes than dynamos. They may be operated by the motor with a friction-pulley, gear or belt. Figure 54 shows one form of a magneto arranged to be operated by the friction pulley on the left-hand end of the armature shaft.

The simplest form of magneto and the one shown in Figure 54 consists of two or more magnets of horse-shoe shape, the ends of which embrace the pole-pieces, between which rotates a shuttle armature wound with small insulated copper wire. Rotation of the armature of the magneto tends to disturb the path of the lines of force or

magnetic flux flowing between the ends of the permanent magnets, which in turn set up powerful induced currents in the armature. The current produced by the magneto is of an alternating



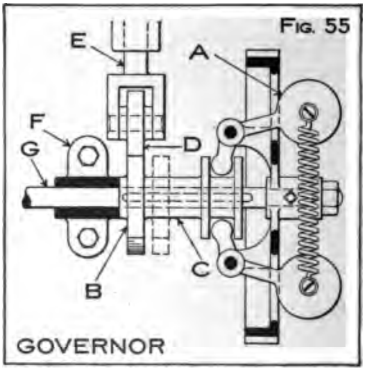
MAGNETO FIG. 54

nature, but converted into a direct or continuous current by means of the commutator on the armature shaft.

Governor, Use of. All explosive motors when running under a heavy load slow down or reduce their speed very materially. If the load be entirely or partially removed from the motor very suddenly, it will tend to race. This racing, which causes excessive wear and vibration, is very injurious to the motor. On light cars with small-powered motors, racing is usually prevented by some form of hand control, such as retarding the ignition or throttling the mixture supply. On heavy, high-powered automobiles, racing of the motor is eliminated by the use of some form of centrifugal governor, which controls the motor-speed

by one of the three following methods: Retarding the ignition—Throttling the supply of mixture—Preventing the exhaust-valve from opening.

Figure 55 shows a form of governor which operates by preventing the exhaust-valve from opening. When the speed of the motor passes its normal limit, the balls A of the governor move out towards the periphery of the gear or wheel which carries them, causing the cam B to be moved to the right by the action of the dogs on the governor arms, which engage in a grooved collar on the sleeve C.



GOVERNOR

The nose of the cam B is thus kept out of engagement with the roller D until the motor resumes its normal speed, thus preventing the valve-lifter from opening the valve.

Normally the cam is held in position by the springs attached to the governor balls, against the shoulder of the bearing F, which carries the cam shaft G.

Grades, Power Required to Climb. Table No. 14 gives the approximate horsepower required

to move a vehicle with a total load of 1,000 pounds, at varying speeds.

Table No. 14.

Horsepower Required to Move a Vehicle Weighing 1000 Pounds.

Per Cent of Grade.	Speed in Miles per Hour.												
	6	8	10	12	14	16	18	20	22	24	26	28	30
5	1.3	1.7	2.1	2.6	3.0	3.4	3.8	4.3	4.8	5.2	5.6	6.0	6.5
6	1.4	1.9	2.4	2.9	3.3	3.8	4.3	4.8	5.3	5.8	6.3	6.7	7.2
8	1.8	2.3	2.9	3.5	4.1	4.7	5.3	5.8	6.4	7.0	7.6	8.2	8.7
10	2.1	2.7	3.5	4.2	4.8	5.5	6.2	6.9	7.6	8.4	9.0	9.6	10.4
12	2.4	3.2	4.0	4.8	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0
14	2.8	3.6	4.5	5.4	6.3	7.2	8.1	9.0	10.0	10.8	11.7	12.6	13.5
16	3.1	4.1	5.0	6.1	7.1	8.1	9.1	10.1	11.1	12.3	13.1	14.1	15.1
18	3.4	4.5	5.5	6.7	7.8	9.0	10.1	11.0	12.1	13.5	14.5	15.6	16.5
20	3.7	4.9	6.1	7.4	8.6	9.8	11.1	12.2	13.5	14.8	15.9	17.2	18.3

Gravity, Acceleration of. Weight is the force apparent when gravity acts upon mass. Mass is matter without reference to weight. When mass or matter is prevented from moving under the stress of gravity, its weight can be appreciated.

v = Velocity in feet per second

t = Time in seconds

h = Height in feet

g = gravity constant = 32.2

$v^2 = 2.g.h$ $\qquad$ $v = \sqrt{2.g.h}$

$h = \frac{g.t^2}{2}$ $\qquad$ $t^2 = \frac{2.h}{g}$ $\qquad$ $t = \sqrt{\left(\frac{2.h}{g}\right)}$

Weight does not enter into consideration in the above formulas. In a perfect vacuum a feather should fall from a given height in the same time that a pound weight would.

Grease Cups—See Lubricators.

High-tension Current—See Electrical Ignition and Induction Coil, also Secondary Current.

Historical Facts. 1803—Principle of the storage battery discovered by Ritter.

1813—Hedley demonstrated by experiment, in England, that traction on rails was possible.

1820—Ampere developed the fundamental laws of electro-dynamics.

1821—Michael Faraday caused a wire carrying an electric current to rotate around a permanent magnet. This was the inception of an electric motor.

1823—The differential-gear movement first invented for use in roving frames by Asa Arnold.

1824—Sturgeon discovered the electro-magnet.

1827—First drop-forging made at Harper's Ferry by J. H. Hall.

1828—Malleable iron discovered by Seth Boyd.

1830—Crucible cast steel first made successfully at Cincinnati Steel Works.

1833—First electric motor made in this country by Saxton.

1834—Prof. Henry made a practical working electric motor.

1838—First two-cycle gas motor patented in England by William Barnett.

1851—Rumkorff invented the jump-spark coil.

1853—First steam motor carriage made in this country by J. K. Fisher, New York.

1859—First practical storage battery made in France by Gaston Plante. Petroleum discovered in United States.

1862—Beau de Rochas first formulated the four-cycle gas motor as afterward built by Professor Otto.

1876—First practical gas motor by Professor Otto in Germany.

1881—Faure type of storage battery first made, now almost exclusively used.

1888—Gasoline first used in a gas motor by Van Duzen of Cincinnati.

Hoods—See Bodies.

Horsepower, of Explosive Motors. A horsepower is the rate of work or energy expended in raising a weight of 550 pounds one foot in one second, or raising 33,000 pounds one foot in one minute. This is far more work than the average horse can do for any great length of time. A good horse for a short period of time can do much more.

As the ordinary formula used for the calculation of horsepower in connection with steam engines is not directly applicable to explosive motor practice, formulas are here given that are more suited to the purpose.

Let D be the diameter of the cylinder in inches, and S the stroke of the piston also in inches; if N be the number of revolutions per minute of the motor, and H.P the required horsepower of the motor, then for a four-cycle motor

$$H.P = \frac{D^2 \times S \times N}{18,000}$$

Example: What horsepower should be developed by a motor of $4\frac{1}{2}$ inches bore and stroke, at a speed of 1,200 revolutions per minute?

Answer: As the bore and stroke of the motor are alike, the square of the bore multiplied by the stroke is equal to the cube of $4\frac{1}{2}$, which is 91.125, this multiplied by 1,200, and divided by 18,000, gives 6.08 as the horsepower of the motor.

From a theoretical standpoint a two-cycle explosive motor should not only have as great a speed but also be capable of developing almost twice the power that a four-cycle motor does. It is a fact nevertheless that its actual performance is far different.

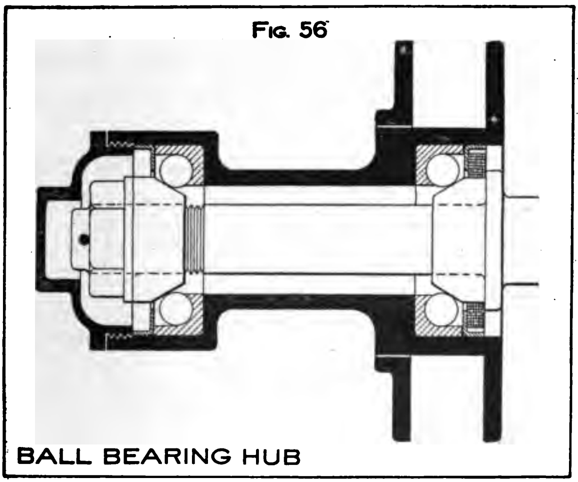
The horsepower of a two-cycle motor may be calculated from the following formula,

$$H.P = \frac{D^2 \times S \times N}{21,000}$$

Example: Required, the horsepower of a two-cycle motor of $4\frac{1}{2}$ inches bore and stroke, with a speed of 900 revolutions per minute?

Answer: The square of the bore multiplied by the stroke is equal to 91.125, which multiplied by 900, and divided by 21,000, gives 3.91 as the required horsepower. The results given by the above examples agree very closely with those obtained from actual practice.

Hubs, Ball and Plain-bearing. The result of experiment shows that the starting friction of

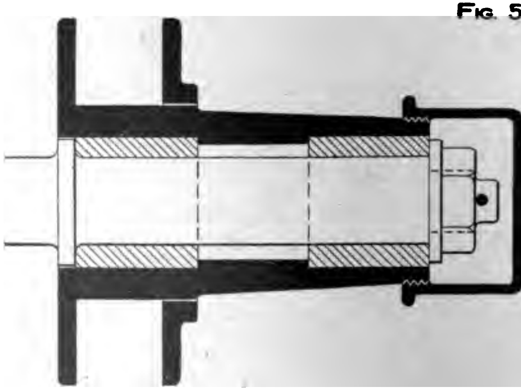


wheel hubs fitted with ball-bearings is far less than that of the most improved design of plain-bearing hubs. Some of the objections to the more extended use of ball-bearings on automobiles are as follows: The concentration of the load on a very small surface—The friction

between the rollers themselves—The need of frequent adjustment. Plain-bearing hubs, while giving somewhat more friction than ball-bearing hubs, require little or no attention, are less in first cost and less liable to injury from road shocks or jars.

Figure 56 shows a ball-bearing hub of neat design and compact form, which is extensively used on motor cars of European make. The hub

FIG. 57



PLAIN BEARING HUB

proper and the removable flange are of cast steel, while the end cap or cover is of bronze with a hexagon for removing or replacing the cap. The grooves or ball races are of rounded form instead of the usual two-point bearing cup.

A plain-bearing hub is shown in Figure 57,

fitted with removable bronze bushings, which may be easily replaced when worn. The space in the center of the hub between the bushings is filled with oil or grease for the purpose of lubricating the spindle of the axle.

The length of the axle-spindle embraced by the bearing should not be less than one-fourth of the wheel diameter.

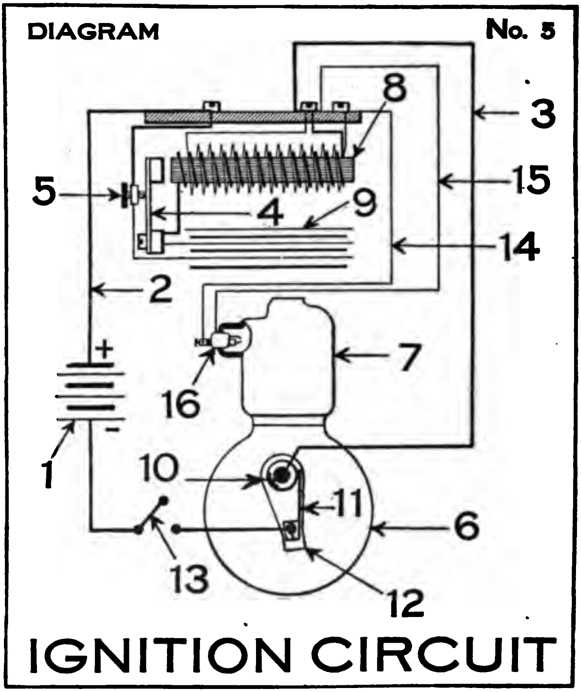
If the axle-spindle be taper, the large diameter should not be less than that of the axle proper.

An axle-spindle equal in diameter to an axle proper of square section, has only 60 per cent of its strength or carrying capacity. A generous fillet should always be left on the axle-spindle next to the flange or collar of the axle.

Ignition, Catalytic. This method of ignition for explosive motors is based on the property possessed by spongy platinum of becoming incandescent when in contact with coal gas or carbureted air. With this means of ignition, speed regulation or variation can only be had within very narrow limits. The principal objections to its extended use are danger of premature ignition, lack of speed control and difficulty of starting the motor.

Ignition Circuit. Diagram No. 5 illustrates the ignition circuit of a single cylinder motor, showing plainly the battery, coil and commutator connections. A reference table accompanies Diagram No. 5, giving the names of the vari-

ous parts shown in the drawing of the ignition circuit.

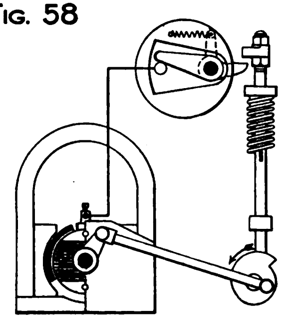


1—Battery.
2 and 3—Primary wires.
4—Vibrator.
5—Contact screw.
6—Crank case.
7—Cylinder.
8—Induction coil.
9—Condenser.
10—Commutator.
11—Contact maker.
12—Commutator case.
13—Switch.
14 and 15—Secondary wires.
16—Spark plug.

Ignition Devices. The device illustrated in Figure 58 consists of a magneto, having a shuttle

type of armature, which oscillates instead of rotating as is usual in other forms of magnetos. In the space between the armature and pole-pieces a shield or tube of soft steel is placed, as shown in the drawing. To one end of this shield a crank is attached, which is operated by a connecting rod from a crank-pin on the cam-shaft of the motor. When the shield or tube is oscillated very rapidly, a current of electricity is induced or created in the wire which composes the winding of the shuttle armature.

FIG. 58



IGNITION DEVICE.

This induced current is led by means of an insulated wire to the make and break device in the combustion chamber of the motor, the other wire being grounded on the frame of the magneto. When the proper time arrives for firing the charge the rod drops into the notch in the cam and the projection upon its upper end strikes suddenly upon the outer end of the contact-arm, causing the electrical circuit to be suddenly broken. At the same time the shield or tube is in the

proper position to cause the maximum current to flow in the winding of the armature coil. No battery or coil is required with this form of ignition. Another form of ignition mechanism has a magneto driven by gearing from the cam-shaft of the motor. The armature terminals of the magneto are connected to two collecting-rings (not a commutator), so that the current given to the induction coil is of an alternating kind, but the electrical circuit is only broken when the alternating current is at its maximum value.

Ignition, Effects of Advancing and Retarding. It should be remembered that ignition timing is not the same thing as ignition governing, therefore to obtain the best results from an explosive motor the charge should be ignited at the best possible moment.

With too early ignition the pressure upon the piston becomes excessive and without any adequate return of useful work or energy. If the ignition be retarded too much, the maximum explosive pressure occurs too late during the working or power stroke of the piston and the combustion of the gases is not complete when the exhaust-valve opens. Greater motor speed requires an early ignition of the charge, but greater power calls for late or retarded ignition.

The reason for advancing the spark when fast running is required, is that the explosion or ignition of the charge is not instantaneous as may

be supposed, but requires a brief interval of time for its completion.

When running a motor with the ignition retarded, the mixture should be throttled as much as possible, otherwise the motor will overheat.

WHEN TO RETARD THE IGNITION. Always retard the ignition before starting the motor, and take great care that the ignition is retarded and not by mistake advanced. Some cars are fitted with a device which prevents the starting crank being turned unless the spark is retarded. If it is not clear as to which way to move the ignition lever, to retard the ignition, move the commutator in the same direction as the cam-shaft rotates.

As soon as the motor slows a little when going uphill, retarding the spark enables more power to be obtained from the motor at the slow speed, that is to say, if the spark is not retarded the motor will go slower than if it is retarded. Do not retard the lever to the utmost under these conditions, on the contrary, retard the lever to such a point that the knocking (due to the wrong position) ceases.

Retarding the spark causes the maximum pressure of the explosion to occur at the best part of the stroke, or, rather, the mean pressure of the explosion stroke will be lower, if the best point of ignition by retarding is not found. This is a matter of some skill and practice.

To slow the motor, cut off as much mixture as

the throttle allows, then slow the motor still further by retarding the spark, but on no account retard the spark when the throttle is full open (for the purpose of slowing the motor), as the motor will merely discharge a quantity of flame at a white heat over the stem of the exhaust valve, burning it, softening it, and making it scale.

Ignition, Electric. Any form of electrical ignition requires some outside source of electric energy such as a generator or battery to produce a spark in the combustion chamber of the motor. A primary or secondary induction coil is necessary in connection with the source of electric energy to give a spark of sufficient intensity to properly ignite the compressed charge in the combustion chamber of the motor. This method of ignition provides a means of varying the motor speed throughout a great range of speeds by advancing and retarding the point of ignition, or time of igniting the explosive charge—see Electrical-Ignition.

Ignition, Hot Tube. The incandescent tube system of ignition consists of a tube of metal or porcelain, one end of which is closed and the other screwed or fastened into the combustion chamber by suitable means.

The flame of a Bunsen burner is projected against the tube, rendering it incandescent, resulting in the firing of the compressed charge slightly before the end of the compression stroke.

This form of ignition has not obtained in automobile practice for several reasons, some of which are here briefly stated. It causes misfiring of the charge on account of either burned or partially consumed gases filling the tube. Again, the tube may be clogged with dead or burned gases almost its entire length, causing premature ignition of the fresh charge of gas in the tube on account of its being too close to the combustion chamber. An almost entire absence of speed regulation of the motor, as the gases require a certain degree of compression to insure proper ignition. Throttling of the charge to obtain a variation in the speed of the motor is therefore almost prohibitive or can only be used within very close limitations.

Ignition, Reason for Advancing Point of. It may be well to explain without entering into theoretical details, that when a motor is running at normal speed, the ignition-device is so set that ignition takes place before the piston reaches the end of its stroke. The later the ignition takes place the slower the speed of the motor and consequently the less power it will develop. If, however, in starting the motor the ignition-device were set to operate before the piston reached the end of its stroke, backfiring would result, resulting in a reversal of the operation of the motor and possibly in injury to the operator.

Ignition Troubles, Causes of. Trouble may occur from the cam or commutator not being

properly adjusted. The contact-screw of the induction coil vibrator may be loose.

The vibrator or trembler of the coil may not be properly adjusted.

To adjust the vibrator, turn the motor crank until the contact is closed, throw in the switch and listen for a good clear buzz from the vibrator. Do not allow it to buzz slowly but fast, until it makes a singing sound like a bumble bee, then turn the crank several times and again listen for the buzz. Sometimes the vibrator will buzz, but it will not buzz when the motor is running fast and the motor misfires; this is probably due to the fact that the adjusting screw has made the tension of the spring too strong and when a quick contact is made it does not have time to vibrate properly. Experience is the only teacher for properly adjusting the vibrator of an induction coil.

Many troubles arise from faulty or defective insulation.

A wire placed too close to an exhaust-pipe invariably fails after a time, owing to the insulation becoming burnt by the heat of the pipe.

A loose wire hanging against a sharp edge will invariably chafe through in course of time.

If the insulation of the coil breaks down it cannot be repaired on the road, it should be returned to the makers. A slight ticking is usually audible inside the coil when this occurs.

All wires where joined together should be

carefully soldered, the joints being afterwards insulated with rubber or prepared tapes. Never make a joint in the secondary wires. See that all terminals are tightly screwed up. When connecting insulated wire, the insulation must be removed, so that only the bare wire is attached. Wires sometimes become broken, and being loose make only a partial contact.

Battery terminals frequently become corroded, they should be covered with vaseline, and require periodical cleaning. See that all connections at the battery are clean and bright.

The porcelain of the spark plug may be cracked and the current jumping across the fracture. The points may be sooty and require cleaning. They may be touching and require separating, or they may be too far apart. The usual distance between the points is about one thirty-second of an inch, which is approximately the thickness of a heavy business card.

Clean all oil and dirt from the commutator. Most commutators are so placed as to give the maximum possible opportunity to collect oil and dirt. They should always be provided with a cover.

In course of time dry or storage batteries will become weak or discharged. Always carry an extra set.

Spanners, oil-cans, tire-pumps, etc., have been known to get on the top of the batteries, thereby

connecting the terminals together and causing a short-circuit.

The platinum contacts of the coil may become corroded. They should be cleaned with a small piece of emery cloth or sandpaper.

The platinum points on the trembler may become loose. They should be riveted up with a small hammer.

It frequently happens that oil and dirt accumulate on the platinum contacts, which interrupt the free flow of the current. Care should be taken, therefore, that they are always perfectly clean.

Indicator Diagrams. The thermal or heat efficiency of an explosive motor may be determined from an indicator diagram, which gives a representation of the internal conditions throughout the entire cycle of operations. The diagram tells many things essential to be known.

It gives the initial explosive pressure, or the pressure a moment after ignition has taken place. It shows whether the volume of the charge is diminished during the period of admission. It gives the point of ignition, when the ignition is complete and when expansion begins. It indicates the pressure of expansion during the working stroke. It gives the terminal pressure when the exhaust is opened. It shows the rapidity of the exhaust. It indicates the back-pressure on the piston, due to the exhaust. It shows the point of opening of the exhaust. It

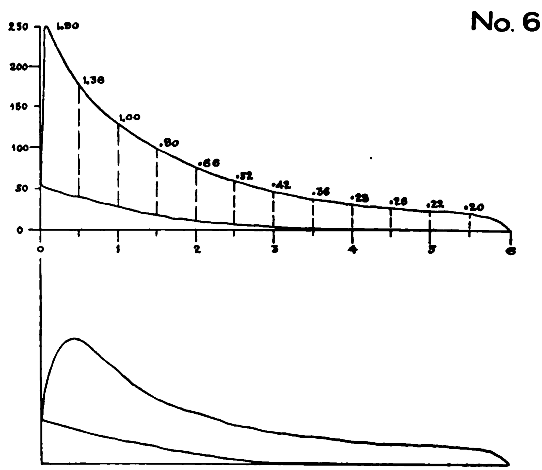
gives the mean power used in driving the motor. It also indicates any leakage of valves or piston.

The usual method of ascertaining the area of an indicator diagram is by means of an instrument known as a planimeter, which is used to calculate the area of any irregular surface, by moving a tracing point attached to the instrument over the entire irregular boundary line of the figure.

But for the purpose of ascertaining the horsepower of a motor it will be sufficiently accurate to illustrate the principles involved, to calculate the area of the diagram by means of ordinates or vertical measurements.

The upper drawing in Diagram No. 6 represents a card taken from a motor of 4 inches bore and 6 inches stroke, with a speed of 900 revolutions per minute, and under a full load. The diagram is divided into 12 parts as shown by vertical lines, the lengths of which are in terms of the spring, which is 100. Then 1.90+1.36+1.00, etc., divided by 12, equals 0.665 as the average height of the diagram. Its length is 6 inches, as shown, therefore the area of the card is approximately 3.99 square inches. As the initial explosive force from the diagram is 250 pounds per square inch, and a 100 indicator spring used, the height of the card is 250 divided by 100, which equals 2½ inches as the height of the card. The mean effective pressure on the

piston in pounds per square inch will therefore be equal to the area of the diagram 3.99, divided by the area of the whole card, which is $2\frac{1}{2} \times 6$, equals 15, and multiplied by 250, the initial explosive



INDICATOR DIAGRAMS

force, or 3.99×250, and divided by 15, equals 66.5 pounds per square inch as the mean effective pressure required.

From this the indicated horsepower of the motor can readily be found as follows:

Let M.P be the mean effective pressure in pounds per square inch, A the area of the cylinder in square inches, S the stroke of the piston in

inches, N the number of explosions per minute, and H.P the indicated horsepower, then

$$H.P = \frac{M.P \times A \times S \times N}{396,000}$$

$$= \frac{66.5 \times 12.56 \times 6 \times 450}{396,000} = 5.69$$

as the required indicated horsepower of the motor. The indicated horsepower of any motor will always be greater than that obtained from a brake test, as it simply represents the actual thermo-dynamic (heat-pressure) conditions within the cylinder, and takes no account of friction and other external losses.

The lower drawing in Diagram No. 6 is a card taken from the same motor running under half load.

Indicator, Use of the. An indicator consists of a cylinder within which works a piston under the tension of a helical spring of predetermined strength. The rod attached to the piston carries a pivoted arm which works on a horizontal lever. This lever carries a pencil bearing against a drum. This drum is so arranged with a spring that it may be partially rotated by the pull on an attached string. A sheet of paper is wound on the drum and held in place by spring clips. The pressure in the cylinder acting on the spring causes the pencil to mark the paper, the indicator card or diagram being traced by the forward and backward movement of the drum.

The most suitable indicator for explosive motors is the McInnes-Dobie. It is fitted with a device which takes a continuous record by means of a rotating drum. Another device is the mirror-indicator of Hospitalier.

Induction Coil. The form of coil generally used on gasoline cars is known as the jump-spark coil. It is of two types, one known as a plain or single jump-spark, the other as a vibrator or trembler coil.

A jump-spark coil consists essentially of a bundle of soft iron wire, known as the core, over which are wound several layers of coarse or large size insulated copper wire, called the primary winding. Over this are again wound a great many thousand turns of very fine or small wire, known as the secondary winding—see also Electrical Ignition.

Inlet-pipe—See Admission-pipes.

Inlet-valve—See Admission-valves.

Inner Tubes—See Tires.

Insulating Material. Asbestos, lava, and mica are severally used for the insulation of spark plugs and sparking devices.

Vulcanized fiber or hard rubber or even hard wood are used for the bases of switches, connection boards, etc.

India rubber or gutta-percha form the basis of the insulated covering of wires used for electrical purposes. The coils of small magnets or the

cores of induction coils are usually wound with cotton covered wire or in some instances the fine w're is silk covered, as in the case of secondary or jump-spark coils.

Intensifier—See Spark Gap, Extra.

Interrupter—See Vibrator Coil.

Joint, Knuckle—See Swivel Joints.

Joint, Universal—See Universal Joints.

Jump-spark Coil—See Electrical Ignition, also Induction Coil.

Kerosene, Use of, in Motor Cylinders. Kerosene injected into a motor cylinder and allowed to remain over night will remove all deposit from the piston head. It should then be blown out through the relief-cock or the exhaust-valve.

Kerosene is also used to remove the gummy residue left on the piston and the cylinder wall by the lubricating oil. When injected into the cylinder in the manner above described, it facilitates the starting of the motor, if it has been standing idle for any length of time.

Figure 59 shows a form of kerosene cup which may be permanently attached to the motor. After removing the cap, the cup is filled and the kerosene admitted to the motor cylinder by depressing the valve-stem.

Kilogram—See Table No. 15.

Kilometer—See Table No. 15.

Knocking, Causes of. Knocking or pounding is an inevitable warning that something is wrong

with a motor. It may be due to any of the following causes:

Premature ignition: The sound produced by premature ignition may be described as a deep, heavy pound.

Using a poor grade of lubricating oil will cause premature ignition. The carbon from the oil will deposit on the head of the piston in cakes and lumps, and will not only increase the compression but will get hot after running a short time and will ignite the charge too early, and thereby produce the same effect as advancing the spark too much. If this is the cause the pounding will cease as soon as the carbon deposit is removed from the combustion chamber.

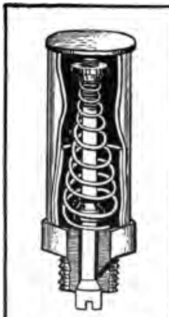


FIG. 59

Badly worn or broken piston-rings.

Improper valve seating.

A badly worn piston.

Piston striking some projecting point in the combustion chamber.

A loose wrist-pin in the piston.

A loose journal-box cap or lock-nut.

A broken spoke or web in the flywheel.

Flywheel loose on its shaft.

If the spark plug be placed so as to be exactly in the center of the combustion space, an objection-

TABLE NO. 15.

ENGLISH AND FRENCH UNITS.

Length.	Centimeter.	Meter.	Kilometer.
Meter	100	1	.001
Kilometer....	100,000	1000	1
Inch.........	2.539	.025	.000025
Foot.........	30.479	.305	.000304
Mile	160,931	1,609.3	1.609

Volume.	Cubic Centimeter.	Liter.	Cubic Meter.
Cubic Inch....	16.386	.0163	....
Fluid Ounce. .	29.572	.0295	....
Gallon.......	3785.21	3.785	.0037
Cubic Foot . . .	28315.3	28.315	.0283
Cubic Yard. . .	764,505	764.505	.7641

Weight.	Gram.	Kilogram.	Metric Ton.
Grain........	.064	....	....
Troy Ounce . .	31.103	.0311	....
Pound Avs. . .	453.593	.4535	.00045
Ton	.091	907.0	1.01605
Metric Ton. . .	1,000,000	1000	1

able knock occurs, which has never been fully explained. In some motors it renders a particular position of the spark control lever unusable; this form of knock disappears either on making a slight advance or retardation of the ignition.

Explosions occurring during the exhaust or admission stroke. This is almost always due to a previous misfire, and it is prevented by stopping the misfires.

If the ignition is so timed that the gases reach their full explosion pressure during the compression stroke, that is, if the spark be unduly advanced when the motor is not running at a high speed, an ugly knock occurs, and great pressure is developed on the crank-pin bearing, wrist-pin, and connecting rod. The result may be the bending or distorting of the connecting rod.

The crank-pin may not be at right angles to the connecting rod. This cause of knock is often hard to find.

The chain may perhaps be loose. This produces a blow if the chain should jump one of the sprocket teeth. The noise is not usually called a knock because it does not recur at uniform intervals. It is dangerous to run with a loose chain, as breakage might precipitate a car down a hill backwards.

The bearings at either end of the connecting rod may be loose. A knock during the explosion

stroke, and also at each reversal of the direction of the piston.

If the crank shaft is not perfectly at right angles to the connecting rod, the crank shaft and fly-wheel will travel sideways so as to strike the crank shaft bearings on one side or the other.

Knuckle-joint—See Swivel-joints.

Lamps—See Gas Lamps.

Leaky Jackets—See Water Jackets.

Leaky Joints. Leaky joints in gasoline or water pipes may be made tight by means of coarse linen or canvas, covered with a paste of litharge and glycerine. This should be again covered with a bandage of adhesive or sticky tape, such as is used for electrical purposes.

Leakage of Water or Gasoline. This is usually due to carelessness, and indicates a slovenly operator. The loss of water, if small, may be left till the run is completed. A leakage of gasoline is far too dangerous to leave alone under any circumstances. A common cause is a minute hole in the float of the carbureter, causing it to flood. The hole can be found by putting the float into boiling water and watching for bubbles.

Learning to Operate a Car. Learn to distinguish normal sound of the motor and its valves, from the following:

Knocking which may be due to a worn or loose bearing.

The absence of explosion in one of the cylinders.

A hissing noise due to leakage of the compression.

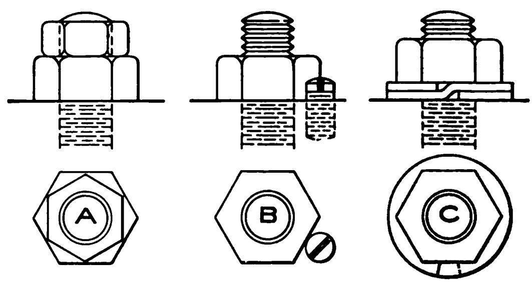
A sharp spitting due to leakage during the explosion stroke.

Any pounding of the admission-valve on its seat.

Any racing of the motor.

The sound of an unoiled or dry bearing.

The rattle of a part becoming loose.



LOCKING DEVICES FIG. 60

Owing to the value of the indications from the above, it is important that no oil-cans, spanners, or other tools, should be left loose in the car.

A little practice will enable the operator to distinguish the beat of the motor and the vibration due to the springs, from the jumping, due to road surface, so as to note at once:

A broken gear tooth.

A loose chain.

A deflated or punctured tire.

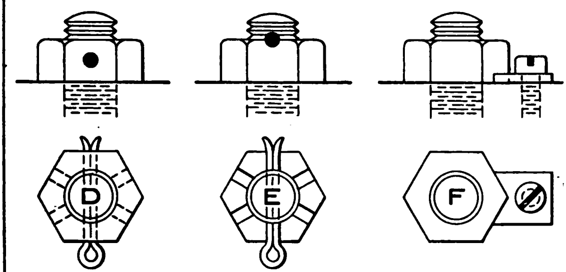
A broken spring.

Ineffectual explosions due to poor compression.

Backlash in steering gear.

Liter—See English and French Units, Table No. 15.

Locking Devices, for Bolts and Nuts. All bolts and nuts upon a motor car which are not provided with locking devices should be inspected at frequent intervals and tightened if necessary. The vibration and jars to which a motor car is



LOCKING DEVICES FIG. 61

subject have an astonishing way of loosening bolts and nuts. Figures 60 and 61 illustrate six different methods of preventing bolts and nuts from becoming loose, by means of

A—A lock-nut, which should be a size smaller than the nut proper, as shown in the drawing.

B—A headless set screw, tapped into the part which receives the bolt.

C—A spring washer under the nut.

D—A split pin through both bolt and nut.

E—A split pin through the bolt only, but fitting in half-round grooves in the nut.

F—A nut-lock with holding down screw.

Loose Connections. These occur in the most peculiar places. Sometimes a platinum tip gets free from its carrying screw, sometimes a lead lug breaks inside a storage battery cell. Sometimes a disconnection occurs by breakage of a copper wire inside its unbroken cover—see also Battery Troubles and Ignition Troubles.

Loss of Power—See Misfiring and Overheating.

Low-tension Current—See Electrical Ignition, also Ignition Devices.

Lubricants, Use of. To ensure easy running and reduce the element of friction to a minimum it is absolutely necessary that all such parts should be supplied with oil or lubricating grease, but it is also a fact, not so well understood, that different kinds of lubricant are necessary to the different parts or mechanisms of a motor car.

As the cylinder of an explosive motor operates under a far higher temperature than is possible in a steam engine, consequently the oil intended for use in the motor cylinders must be of such quality that the point at which it will burn or carbonize from heat is as high as possible.

While a number of animal and vegetable oils have a flashing point, and yield a fire test

sufficiently high to come within the above requirements, they all contain acids or other substances which have a harmful effect on the metal surfaces it is intended to lubricate.

The general qualities essential in a lubricating oil for use in motor cylinders include a flashing point of not less than 360 degrees Fahrenheit, and fire test of at least 420 degrees, together with a specific gravity of 25.8.

At 350 to 400 degrees Fahrenheit, lubricating oils are as fluid as kerosene, therefore the adjustment of the feed should be made when the lubricator and its contents are at their normal heat, which depends on its location in the car. Steam engine oils are unsuitable for the dry heat of motor cylinders in which they are decomposed whilst the tar is deposited.

All oils will carbonize at 500 to 600 degrees Fahrenheit, but graphite is not affected by over 2,000 degrees Fahrenheit, which is the approximate temperature of the burning gases in an explosive motor. The cylinder of these motors may attain an average temperature of 300 to 400 degrees Fahrenheit. So that graphite would be very useful if it could be introduced into the motor cylinder without danger of clogging the valves and could be fed uniformly. These difficulties have not yet been overcome. Graphite is chiefly useful for plain-bearings and chains.

The film of oil between a shaft and its bearing

is under a pressure corresponding to the load on the bearing, and is drawn in against that pressure by the shaft. It might not be thought possible that the velocity of the shaft and the adhesion of the oil to the shaft could produce a sufficient pressure to support a heavy load, but the fact may be verified by drilling a hole in the bearing and attaching a pressure gauge.

Roller and ball-bearings provide spaces, in which, if the oil used contains any element of an oxidizing or gumming nature, a deposit or an adhesive film forms upon the sides of the chamber, the rollers or balls, and the axle. This deposit will add to the friction, hence it is the more important to use a good oil or a petroleum jelly in such bearings.

Air-cooled motors, being hotter than water-cooled, must have a different lubricant, or one capable of withstanding higher temperatures.

The effect upon animal or vegetable oils of such heat would be to partially decompose the oils into stearic acids and oleic acid and the conversion of these into pitch. Such oils are therefore inadmissible for air-cooled motor use.

Mineral oils are not so readily decomposed by heat, but at their boiling points they are converted into gas, and any oil, the boiling point of which is in the neighborhood of the working temperature of the motor cylinder, is useless, as its body is too greatly reduced to leave an effective

working film of oil between the cylinder and the motor piston.

The essentials for the proper lubrication of air-cooled motors are:

That the oil should not decompose.

That it should not volatilize, as this will result in carbon deposits.

That its viscosity should be equal to that of a good steam engine oil at similar temperatures.

That it should be fluid enough to permit of its easy introduction into the cylinder.

That it will have no corrosive effect on the cylinders and no tendency to gum.

That it will not oxidize with exposure to air and light.

Lubrication, Splash and Pressure Feed. Some makes of vertical cylinder motors use the splash system, whereby oil fed by gravity from a tank above the level of the crank-case flows into the crank-case, whence it is splashed over the piston and the wrist and crank-shaft bearings. The large end of the connecting rod, which works in the crank-case, is made to dip or splash into a bath of oil. This lubricates the crank-pin. The splashing is invariably utilized to lubricate the cylinder by wetting the bottom of the piston and splashing into the cylinder. A little ring is sometimes made in the crank-case, into which the oil collects and into which also the end of the piston dips. The oil usually requires changing

every 100 miles on small motors or every 75 miles on large.

Figure 62 shows a vertical cylinder motor using splash lubrication.

With the use of high-speed gasoline motors, it has been found necessary to use a forced circulation of the oil in order to completely lubricate the interior of the cylinder. The usual method with high-powered motors is to employ a belt-driven pump to force the oil through adjustable conduits to the various moving parts. Such pumps, operating in ratio to the speed of the motor, supply lubricant more rapidly as the motor speed increases, and less as it decreases. Thus, a perfect supply is maintained, on the one hand, and flooding of the motor is prevented on the other.

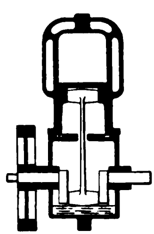


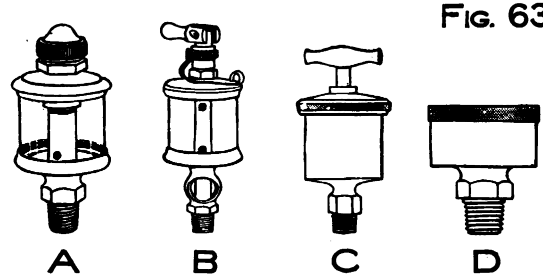
FIG. 62

Where horizontal cylinders are used, it is customary to use grease cups, and to control the feed by mechanical or spring pressure. Such devices are less suitable for vertical cylinder motors, which require oil in large quantities and exact adjustment in its flow. One very useful feature of oil pump lubrication is that the flow of oil may be kept in proportion to the speed of the motor. This is a very necessary feature, as without it flooding is liable to result.

Lubricators. It should be ascertained from the maker of the car, how many drops of oil per minute are necessary for the different mechanisms of the car, including the motor. The lubricators should then be set accordingly.

It should be remembered that in cold weather when the oil is thick a different adjustment of the lubricators will be necessary from that found suitable in warm weather. It is important that

FIG. 63



LUBRICATORS

the lubrication should be regular, and good oil used, but not too much. Too much oil will foul the spark plugs, clog the valves, and interfere with the quality of the explosive mixture. For this reason the lubricators should always be carefully closed when the car is stopped. If a mechanical lubricator is used, examine the mechanism sometimes, and do not trust entirely to the feed. If a pressure lubricator is used, see

that the piston or cap is tight, for if not the pressure will stop the lubrication.

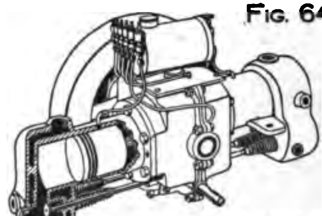
It sometimes happens that an oil pipe or oil hole is stopped up and needs cleaning, or perhaps the plug at the bottom of the crank chamber has come unscrewed and dropped out, losing all the oil. The proper amount of oil in the crank-case is about half a pint. An extra lubricator leading to the cylinders and crank-case should be fitted, so that extra oil can be fed by a hand pump, if there is any doubt about the motor getting enough.

Figure 63 shows four forms of lubricators for automobile use.

A—Plain, glass body oil cup, feeds only when shaft is running.

B—Sight feed, glass body oil cup, has an index-arm on top which indicates whether the oil feed is off or on.

FIG. 64



LUBRICATOR

C—Pressure feed, piston form of lubricator, for heavy bodied oil; the oil is forced into the bearings by means of a spring-actuated piston in the lubricator.

D—Plain grease cup, oil or grease forced into the bearing by screwing down the cap.

A form of pressure lubricator is illustrated in Figure 64, in which a slight pressure from the crank-case of the motor causes the oil to be forced through the pipes leading to the different parts of the motor. This form of pressure lubricator is only applicable to opposed-cylinder motors with enclosed crank-case, as shown in the drawing, or to vertical two-cylinder motors with both pistons connected with one common crank-pin.

Machine Screws, Dimensions of—See Table No. 16.

TABLE NO. 16.

DIMENSIONS OF MACHINE SCREWS.

Number of Screw.	Threads per Inch.	Diameter of Body.	Diameter at Bottom of Thread.	No. of Tap Drill for Full Thread.	No. of Drill for Body.	Diameter of Head.		
						Flat Head.	Button Lead.	Philister Head.
2	56	.084	.053	54	44	.16	.15	.13
4	36	.110	.062	52	34	.22	.20	.17
6	32	.136	.082	45	28	.27	.25	.22
8	32	.163	.109	35	19	.32	.29	.26
10	32	.189	.135	29	11	.37	.35	.30
12	24	.216	.144	27	2	.43	.39	.34
14	20	.242	.156	22	$\frac{1}{4}$	.48	.44	.39
16	20	.268	.182	14	$\frac{9}{32}$	.53	.49	.43
18	18	.294	.198	8	$\frac{19}{64}$	.58	.52	.47

Manometer. A device for indicating either the velocity or the pressure of the water in the cooling system of a gasoline motor.

Magneto—See Generator.

Materials, Strength and Weight of—See Table No. 17.

TABLE NO. 17.

STRENGTH AND WEIGHT OF MATERIALS.

Material.	Tensile Strength in pounds per square inch.	Resistance to Compression.	Weight per cubic inch.	Weight per cubic foot.
Aluminum	12,000	......	.094	162
Brass—Cast.........	18,000	10,000	.290	504
Sheet........	23,000	12,500	.295	510
Bronze—Aluminum ..	60,000	12,000	.290	500
Phosphor ...	63,000	12,000	.300	530
Copper—Cast........	18,000	30,000	.313	542
Sheet.......	30,000	40,000	.317	548
Wire	50,000	......	.317	548
Gun Metal	36,000	15,000	.290	504
Iron—Cast..........	16,000	100,000	.260	450
Malleable......	18,000	80,000	.267	460
Wrought......	50,000	36,000	.280	480
Lead	33,000	......	.410	711
Steel—Tool.........	100,000	40,000	.284	490
Cr. Cast	63,000	36,000	.284	490
Mild	60,000	36,000	.284	490
C. Rolled	63,000	40,000	.284	490
Tin.................	4,600	......	.265	459
Zinc................	8,000	......	.247	438

Mensuration of Surface and Volume. Area of rectangle = length × breadth.

Area of triangle = base × one-half the perpendicular height.

Diameter of circle = radius × 2.

Circumference of circle = diameter × 3.1416.*

Area of circle = square of diameter × .7854.*

* See Table No. 6, Areas and Circumferences of Circles.

Area of sector of circle = area of circle × number of degrees in arc ÷ 360.

Area of surface of cylinder = circumference × length, plus the area of both ends.

To find diameter of circle, having given area: Divide the area by .7854, and extract the square root.

To find the volume of a cylinder: Multiply the area of the section in square inches by the length in inches = the volume in cubic inches. Cubic inches divided by 1728 = volume in cubic feet of any body.

The surface of a sphere = square of diameter × 3.1416.

Volume of a sphere = cube of diameter × .5236.

The side of an inscribed cube = radius of the sphere × 1.1547.

The area of the base of a pyramid or cone, whether round, square or triangular, multiplied by one-third of its height = the volume.

A gallon of water (United States Standard) weighs 8⅓ pounds and contains 231 cubic inches. A cubic foot of water weighs 62½ pounds, and contains 1,728 cubic inches, or 7½ gallons.

Each nominal horsepower of a boiler requires one cubic foot of water per hour.

To find the internal area of a pipe, the volume and velocity of the fluid or gas being given: multiply the number of cubic feet by 144, and divide the product by the velocity in feet per

minute. The area being found, it is easy to find the diameter of pipe necessary.

To find the pressure in pounds per square inch of a column of water of given height: Multiply the height of the column in feet by .434. Approximately, every foot elevation is equal to one-half pound pressure per square inch.

To find the velocity in feet per minute necessary to discharge a given volume of fluid or gas in a given time: Multiply the number of cubic feet by 144, and divide the product by the internal area of the pipe in inches.

Metals, Melting Point of—See Table No. 18.

TABLE NO. 18.

MELTING POINT OF METALS.

Metal.	Temperature in Degrees Fahrenheit.	Metal.	Temperature in Degrees Fahrenheit.
Aluminum	1160°	Lead	620°
Bronze	1690°	Platinum	3230°
Copper	1930°	Silver	1730°
Gold	1900°	Steel	2400°
Iron—Cast	2000°	Tin	445°
Wrought	3000°	Zinc	780°

Mica, Use of—See Insulating Material.

Misfiring, Causes of. Misfiring means failing to fire every charge that the motor takes.

One of the most common causes of misfiring is an improper mixture of gasoline and air. Too

much air or too much gasoline will cause misfiring.

Batteries which are almost exhausted will give rise to explosions in the motor cylinder which seem all the more violent on account of their irregularity. This should be the time to switch on an extra set of batteries, if one is carried. It is perfectly useless to connect a set of exhausted cells with a new set, either in series or parallel, as it will reduce the new cells nearly to the voltage of the exhausted ones.

Closing the points of the spark plug will help the batteries somewhat and may enable the operator to get the car home.

Examine the battery and all its connections at the terminals, and determine whether the battery is exhausted or not, whether there are broken connections, whether the terminals or other points need cleaning or attention otherwise. Also ascertain whether the fuel is being fed to the motor in proper quantities. It may not be getting enough at each charge or perhaps too much.

Short-circuits and current leakage by contact of a bare place on a wire with some metal portion of the car, or by a spark plug with defective insulation will also cause the motor to misfire. The spark may arc or jump elsewhere than between the platinum points of the plug, rendering a new plug or fresh insulation necessary.

A loose connection in the primary or secondary

circuit is another source of misfiring. A loose wire may be in contact and allow one or two explosions to take place. The vibration of the car afterwards may shake the wire loose from its contact and then the motor will misfire. All connections should be carefully cleaned and screwed tight.

If the spark plug is covered with soot or grease misfiring will often result. A spark gap device placed in the secondary circuit will generally overcome this difficulty, but prevention is better than cure and over-lubrication should be avoided and the best grade of cylinder oil used.

Mixing Valves—See Carbureters.

Motor, Electric—See Electric Motors.

Motor, Four-cycle—See Explosive Motors, also Four-cycle Motor.

Motor, Gasoline—See Explosive Motors, also Gasoline Motor Construction.

Motors, Speed Regulation of Gasoline. To secure the greatest efficiency and power of the motor it is necessary to be able to control its speed, and there are various ways to accomplish this object. The range of speed of different motors varies considerably. With small single-cylinder motors it is necessary that the speed should be very great in order to secure sufficient power, while with two and four-cylinder motors this is not necessary, and consequently they are more durable. As a rule the speed varies from

about 750 revolutions per minute for the latter to 1,500 for small motors.

There are various methods of governing, which are enumerated and described herewith.

Advancing or retarding the ignition.

Exhaust-valve lifter.

Exhaust-valve regulator.

Regulating the lift of the admission-valve.

Mechanically governing the exhaust-valve.

Advancing or retarding the ignition. This is the method adopted for single and double-cylinder motors, and consists in changing the time at which the spark occurs in the combustion chamber by means of a small lever. If the full force of the explosion occurs in the combustion chamber at the moment when the piston is at the end of its stroke, its effect will be greatest. The duration of pressure on the piston can be reduced by altering the timing of the spark, so that it occurs after the piston has passed the end of the stroke. This is the simplest method, but its proper use depends largely on the skill and experience of the operator. When this method is adopted, a throttle is also used, which enables the operator to regulate the quantity of mixture, and alter the power of the explosion. When the maximum power is required, the throttle is wide open, and the spark advanced to the utmost.

Exhaust-valve lifter. This operates by preventing the exhaust-valve from closing after the

exhaust gases have escaped. When the exhaust-valve is held up, no explosive charge is taken into the cylinder.

Exhaust-valve regulator. This method consists in regulating the lift of the exhaust-valve, but does not prevent the valve from closing in the usual manner. It is also used in connection with the spark advance. When the maximum power is required, the exhaust-valve is not interfered with, and opens to its fullest. When less power is required, the exhaust-valve is prevented from opening as much. Consequently the exhaust gases are not fully expelled, and as they partially fill the space in the combustion chamber, a full charge of mixture cannot be admitted through the admission-valve, and the force of the explosion is weakened.

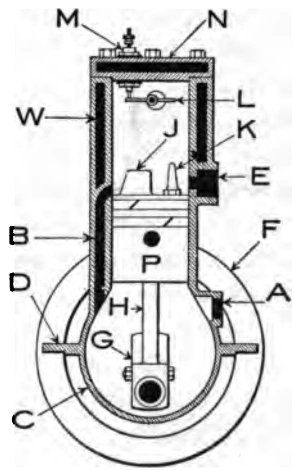
By regulating the lift of the admission-valve. By increasing the strength of the valve spring, the admission-valve is prevented from opening to its fullest extent, and a full charge is not admitted to the combustion chamber.

By mechanically governing the exhaust-valve. This is effected by preventing the cam from lifting the exhaust-valve after an explosion has taken place. This system is adopted on two and four-cylinder motors, and is the one most generally used on cars of European make.

Motor, Two-cycle. Figure 65 shows a vertical cross-section of a two-cycle type of motor:

that is to say, it shows the motor as it would appear if cut in two directly through the center. This type of motor is particularly adapted to marine purposes on account of its simplicity, absence of gearing and the slight knowledge required on the part of the operator to handle it successfully. This form of motor, however, has not been found the most satisfactory for automobile use. Its cycle of operation is fully described under Explosive Motors.

FIG. 65



TWO-CYCLE MOTOR

C is the crank chamber. It has two feet, or lugs, D as shown in the drawing, for the purpose of attaching it to its position in a boat or elsewhere. There is an opening at A for the reception of the mixing-valve. The flywheel F, crank shaft G, connecting rod H, piston P, inlet-port B, baffle-plate J and exhaust-opening E, are plainly shown in the drawing.

To the top of the piston P is attached a cone-pointed projection K. This is on the right-hand side and is placed there to break the electrical circuit between the contact-points of the igniter. This is effected by the cone-point K striking the right-hand end of the lever L, which causes the lever to rise at that end and fall at the other, thus breaking the contact between it and the insulated igniter terminal M. This breakage of the circuit causes a spark to occur between the left-hand end of the lever L and the point with which it was, a moment before, in contact. This action takes place once in each revolution of the motor and just before the piston reaches the end of its upward stroke.

The ignition may be retarded or advanced by raising or lowering the fulcrum of the lever L, by means of the eccentric shown.

The upper part of the cylinder is incased by a water jacket W, as is the cylinder head or cover N.

While it may seem possible that the two-cycle motor should be capable of a higher degree of power, as well as a greater speed than a four-cycle motor, the reverse is true in its practical performance. It is a very satisfactory type of motor for low or medium speeds, and under such conditions it is claimed that it will develop at least 30 per cent more power than a four-cycle motor. At high speeds, such as are needed in

explosive motors for automobile use, the objection to the two-cycle motor is that, all the functions of admission, compression, explosion and exhaust being in a single revolution of the motor, sufficient time is not allowed for the expulsion of the burned gases, with the result that the cylinder chokes itself up, and the quality of the mixture consequently falls below the explodable point.

While a four-cycle motor of a given power will run as high as 1,000 to 1,200 revolutions per minute, a two-cycle motor of the same dimensions will not run over 750 to 900 revolutions. It is on this account that the two-cycle motor has so far not proved as successful as might have been expected for automobile use.

Motor Troubles—See Battery, Carbureter and Ignition Troubles, also Misfiring and Overheating.

Mud-guards. On many cars the mud-guards are a constant source of trouble, due to improper methods of attaching them to the frame or body of the car. The attaching bolts should be of large size and the irons to which the mud-guards are fastened should be much larger than the mere weight of the guards warrant. The guards should be strong enough to withstand any or all of the following conditions:

A heavy wind pressure, especially a head or partial side wind.

Motor vibrations and road jars.

The weight of some idiot who insists on leaning on them when the car is standing.

Muffler. The exhaust-pipe from the motor which conducts off the gases after they have done their work in the cylinder is connected to a chamber, called a muffler, attached to the frame of the car. The object of the muffler is to deaden the noise of the escaping gases by:

Breaking up the gases into a number of fine streams.

Allowing the gases to expand and cool.

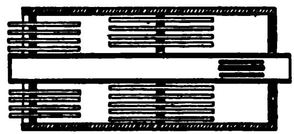
Checking the velocity without putting too much back pressure on the motor.

Reducing the pressure of the gases till they are as nearly as possible at atmospheric pressure.

To do this, the chamber is divided up into two or more compartments, and the gases in their passage from one to the other have to pass through baffle-plates or tubes, drilled with a number of fine holes, the combined area of which must be considerably in excess of the area of the exhaust-pipe, to allow of a free passage for the expanding gases. The flow is thus broken up and subdivided into a number of fine streams of cool gas at or near atmospheric pressure, which cause little or no noise on their escape into the air. It is the sudden expansion of the gases at a high pressure which causes the noise at the exhaust-opening of the motor.

Figure 66 illustrates a form of muffler with a central inlet-pipe, provided with slotted openings as shown. The chamber is divided into two parts by a plate, in and around which are located a number of small tubes for the passage of the gases. A similar set of tubes are located in the discharge end of the muffler.

FIG. 66



MUFFLER

Muffler Cut-out. A cut-out is a very desirable addition to a good muffler, not only for the extra power gained by its use, but when adjusting the motor it is sometimes necessary to listen to the sound of the exhaust to ascertain if the motor is working properly.

Needle-valve—See Valves.

Negative Pole—See Current, Direction of, also Polarity.

Nuts, Locking Devices for—See Locking Devices.

Oil—See Lubricants.

Oil Pump—See Oilers, Ratchet-feed and Rotary.

Oilers—See Lubricators.

Oilers, Ratchet-feed and Rotary. Mechanical or power-operated lubricators are of two kinds:

The first has the piston or plunger cams operated by means of a pawl and ratchet-wheel, through a connecting rod attached to some reciprocating part of the motor, or to a crank on the end of the cam shaft. The second form has its pump shaft driven by a belt, chain or gear from the motor. The ratchet-feed oilers are not suitable for motor speeds over 600 revolutions per minute, while the rotary oiler may be used with motors of any speed by the use of a simple form of reducing gear.

Overcharging—See Storage Batteries.

Overheating, Causes of. The immediate effect of overheating is to burn up the oil in the cylinders or crank case. This causes a smell of burning and an odor of hot metal. There is sometimes a slight smoke and the motor will make a knocking sound. The cooling water begins to steam, and the car will gradually slow down and finally stop.

The most serious cause of a stoppage on the road is overheating, which causes the lubricating oil to burn up and the piston to expand and grip or seize in the cylinder.

Insufficient lubrication increases the friction between the piston and cylinder, and so generates extra heat. Bad or unsuitable oil may have the same effect.

Too much mixture or too rich a mixture also causes increased heat.

Any failure in the water circulation, unless detected at once, will cause overheating, the results of which may prove very serious. For this reason a careful watch should be kept on the manometer. If this useful device is not fitted, the motor and pipes should be felt by the hand.

As soon as any of the above symptoms are noticed:

The motor should be stopped at once.

Kerosene should be copiously injected into the cylinders and the motor turned by hand to free the piston-rings.

The parts should then be allowed to cool.

Do not pour cold water on the cylinder jackets, for fear of cracking them, but pour the water into the tank so as to warm the water before it reaches the cylinder jackets.

A simple test in the case of an overheated motor is to let a few drops of water fall on the head of the cylinder. If it sizzles for a few moments the overheating is not bad, but if the water at once turns into steam, the case is serious.

Detach the spark plug or plugs, and turn the starting-crank slowly. This draws in cold air and cools the inside of the cylinder and the piston.

Packing. Packing or material for making gas or water-tight joints is of various kinds. Asbestos packing comes in sheets, called asbestos paper or board, in the form of woven cloth, and also as

string or rope. Rubber packing is made in sheets, either plain or with alternate layers of canvas and rubber. Some forms of packing are known as Rubberbestos and Vulcabestos and are made of asbestos, impregnated with rubber and afterwards vulcanized.

Parts, Extra. The necessity for carrying extra parts upon a car becomes more apparent when a breakdown occurs miles away from home, and no material at hand to repair the break with. The accompanying list gives some of the parts generally needed in time of trouble:

Bolts and nuts.	Inner tube.	Split pins.
Chain links.	Insulated wire.	Sticky tape.
Dry batteries.	Packing.	Valve springs.
Extra valves.	Spark plugs.	Washers.

Picric Acid. Gasoline will absorb or take up about 5 per cent of its weight of picric acid. The addition of a small quantity of kerosene will enable the gasoline to absorb about 10 per cent of picric acid.

Picric acid is only dangerous when fused, or when in a highly compressed state.

An increase in motor efficiency of about 20 per cent is claimed for the picric-gasoline mixture.

About three-tenths of a pound of picric acid is required for each gallon of gasoline. The mixture should be allowed to stand for two days, agitating occasionally during this time, then strain through two or three thicknesses of very fine muslin before using.

The explosive force of picric acid is very much overrated. If thrown upon a red hot plate of iron, it simply burns with a smoky flame, and striking a small quantity of it upon an iron anvil will not explode it.

Pipe Nipples. Nipples are always ordered by the nominal diameter of the pipe and the over-all length of the nipple. Table No. 19 gives the standard lengths of nipples of varying diameters, also the number of threads per inch and the outside diameter of the pipe.

TABLE NO. 19.

LENGTH OF STANDARD PIPE NIPPLES.

Nominal Diameter.	Outside Diameter of Pipe.	Threads per Inch.	Over-all Length of Nipples.					
			Close.	Short.	Long.			
1/8	.40	28	3/4	1 1/2	2	2 1/2	3	3 1/2
1/4	.54	18	7/8	1 1/2	2	2 1/2	3	3 1/2
3/8	.68	18	1	1 1/2	2	2 1/2	3	3 1/2
1/2	.84	14	1 1/8	1 1/2	2	2 1/2	3	3 1/2
3/4	1.05	14	1 3/8	2	2 1/2	3	3 1/2	4
1	1.32	11	1 1/2	2	2 1/2	3	3 1/2	4
1 1/4	1.66	11	1 5/8	2 1/2	3	3 1/2	4	4 1/2
1 1/2	1.90	11	1 3/4	2 1/2	3	3 1/2	4	4 1/2
2	2.38	11	2	2 1/2	3	3 1/2	4	4 1/2

Pipe, Wrought Iron—See Table No. 19.

Pistons. The piston used in a gasoline motor cylinder is of the single-acting or trunk type. It is made of an iron casting which is a good working fit in the cylinder. Around the upper end of the piston three or four grooves are cut, and in these grooves the piston-rings fit. The rings are made of cast iron, and the bore of the ring being eccentric to its outer diameter, there is a certain amount of spring in them, and so pressure is caused against the cylinder wall, preventing any of the expanding gases passing the piston.

The lubrication of the piston-rings is very important, for on that depends the proper working of the piston in the cylinder. In single-cylinder motors, the piston-rings require frequent attention, and kerosene should be injected into the spark plug opening at frequent intervals. Occasionally the cylinder should be taken off, and the rings cleaned with a brush and kerosene. In multi-cylinder motors, this constant attention is not required, for in addition to the splash system of lubrication, usually, there are pipes leading to the cylinders, through which oil is fed and so keeps them well lubricated. The speed of the motor being so much less, there is no danger of the oil being used up rapidly.

Piston Displacement. The piston displacement of a motor is the volume swept out by the piston, and is equal to the area of the cylinder

multiplied by the stroke of the piston. The expression, cylinder volume, is sometimes confounded with the term piston displacement. This is erroneous, as the cylinder volume is equal to the piston displacement, plus the combustion space in the cylinder head.

Pistons, Length of. For vertical cylinder motors the length of the piston should not on any account be less than its diameter, while a length equal to one and one-quarter or even one and one-third diameters is better. For motors with horizontal cylinders the length of the piston, in any case, should not be less than one and one-third diameters, and if possible one and one-half diameters or over.

Piston-rings. To ensure proper compression, it is absolutely essential that the piston-rings should be kept lubricated; consequently when the motor has been idle for some time, the compression at the start is often poor. Any failure in the lubrication while running will, of course, have the same effect, such, for example, as in the case of overheating, or when the supply is intermittent. Sometimes the piston-rings get stuck in their grooves with burnt oil, through overheating, and the compression escapes past them. Thorough cleaning with kerosene and fresh lubricating oil will settle the matter. In motors where the rings are not pinned in position, the slots may work round so as to coincide. In this case they

will have to be moved around. Sometimes burnt oil may, apparently, have the opposite effect on piston-rings, for by causing the piston to grip in the cylinder, it will produce considerable resistance, and the operator might erroneously think in consequence that his compression is good. In every case, after a long run, a little kerosene should be injected into the cylinders to clean the rings.

Piston-rings, Method of Turning. A pattern should be made from which to cast a blank cylinder or sleeve with two projecting slotted lugs on one end to bolt same to face plate of lathe. This blank should first be turned off outside to the required diameter, making it, of course, sufficiently larger to allow for the cut in the rings, after cutting from the blank. The blank should then be set over eccentric sufficiently to allow the thick side of the rings to be twice the thickness of the thin side after turning. The inside of the blank can then be bored out, and the rings cut off to the exact thickness required with a good sharp cutting off tool. A mandril or arbor should be made with two cast iron washers or collars to fit on it, one fastened to the mandril and the other loose, with lock nut on mandril with which to tighten up the loose collar. After the rings have been sawed open and a piece cut out the required length, they can be placed in a collar or ring about 1-32 to 3-64 of an inch larger than

the cylinder bore, and slipped on to the mandril one at a time of course, with the loose collar and nut off the same. The loose collar and nut can then be put on the mandril, the ring clamped tightly between the two collars, the mandril put in the lathe and the ring turned off, without leaving any fins or having to cut the ring off afterward as is done in many cases. This is the only way in which a perfectly true ring can be made.

Piston Velocity, Limitation of. The speed of rotation of an explosive motor is limited by the fact that the velocity of the piston must be considerably less than the rate of combustion of the explosive mixture, in order that the motor may develop energy or do work. The practical limit of piston velocity is said to be between 14 and 16 feet per second.

Plain-bearing Axles—See Axles.

Plain-bearing Hubs—See Hubs.

Platinum. The contact points of the vibrator of an induction coil should always be of platinum. German silver or any other metal spoils the quickness of the break on account of the greater tendency of the contact-points to carbonize, when of any other metal than platinum. Spark plug points should also be of platinum or iridio-platinum, which is better yet, as it is more capable of withstanding the intense heat in the combustion chamber than the platinum itself. Any

other metal than platinum (except gold) will turn green or black if tested with nitric acid.

Points to Learn. If a motor does not ignite its first charge there is a cause for it, and no amount of turning of the crank will locate it. A little common sense will not only locate but remove the cause, and the motor will do its own turning after the first two or four revolutions.

See that every charge the motor takes in is exploded, for which a proper mixture and a good spark are necessary.

Never throttle the mixture so closely that the motor cannot get a full charge every time it needs it.

Always use the very best cylinder oil in the cylinder, and a good quality of lubricating oil in the crank case.

Learn how to properly adjust the vibrator of the coil.

Learn how to set the valve gear correctly.

Learn how to locate and remedy loss of compression in the motor.

Learn how to fix a bearing or piston which has seized.

Always throw the clutch, throttle or spark-advance levers in gradually.

Buy a densimeter, and learn how to test the quality of the gasoline.

Learn how to grind in the valves, also how to fit new piston-rings.

Never leave the car with the motor running. A slight touch of the clutch-lever may cause the car to run away.

See that the water-cooling system has a drain-cock so that the water can be drained in the winter.

Once a month wash out the pipes, water jacket and water tank with a strong solution of common soda or lye. Let the motor run a few minutes before emptying the solution, then empty the tank and pipes and repeat the operation with clean water. This process will tend to insure uniformly effective circulation of the water.

Never pour gasoline near a naked flame. It is safer to extinguish all except electric lights, when filling the gasoline tank of a car.

Always remember that gasoline is a highly volatile and inflammable liquid and its vapor is far more inflammable when mixed with air.

If the motor works well, leave it alone, although it may never seem speedy enough.

Points to Remember. That if a motor nearly stops and then goes on again, it is due to lack of gasoline at the carbureter. There is probably dust, dirt, or other deposit at the inlet of the carbureter, which, however, sometimes frees itself. To avoid these troubles gasoline should never be poured into the tank except through a funnel fitted with a fine gauze strainer or a piece of muslin.

That an unusual noise or squeak is evidence of lack of lubrication, and generally foretells a breakdown unless looked after at once.

That air must always find an inlet to the gasoline tank in order that the gasoline may flow out freely, and considerable trouble has been caused by the vent-hole in the cap of the gasoline tank becoming blocked.

That the motor will not run unless the gasoline is flowing from the tank to the carbureter.

That the motor will not start if the switch-plug is in your pocket.

That the motor will not start until the switch is turned on.

That there must always be good electrical connections between the battery, spark coil and spark plug.

That too much lubricating oil must not be used. It causes: the valves to stick, a deposit on the spark plugs, and a poor combustion in the cylinder. Excess of lubricating oil reveals itself in the form of smoke at the exhaust.

When the motor is in proper working order, and turned with the crank, a considerable resistance should be felt at every alternate back stroke of the piston. This back pressure should require a considerable effort to overcome when the crank is turned slowly. If the compression of any cylinder is poor, that cylinder will not give its full power,

Finally, remember that if your motor is misfiring or not running properly, the trouble may of its own accord disappear after a little running.

Polarity. To ascertain the polarity of the terminals of a storage battery or light circuit, place the ends of the wires on the opposite ends of a small piece of moistened litmus paper. The wire on the side of the paper which has turned red is the negative pole of the battery—see also Current, Direction of.

Porcelain. Porcelain tubes used for the insulation of the center rod of a spark plug, have higher insulative properties than lava or mica, but on account of the liability of the porcelain to break from too sudden change of temperature, it is not as reliable as other forms of insulating material.

Positive Pole—See Current, Direction of, also Polarity.

Power, Loss of—See Misfiring and Overheating.

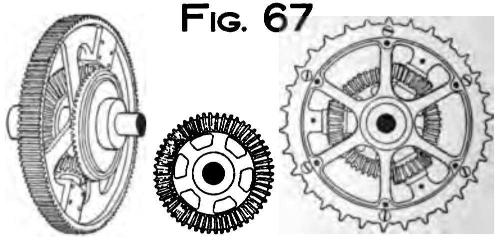
Power Transmission Devices. The power transmitting devices or mechanisms used on gasoline motor-cars may be divided into three classes: The **Differential gear** which transmits the power from the speed-change-gear to the rear-axle or wheels of the car. The **Friction-clutch** which forms the connecting and disconnecting medium between the motor and the speed-change-gear. The **Speed-change-gear** which

transmits the power of the motor to the differential gear at varying speeds, entirely independent of the motor speed.

DIFFERENTIAL GEARS. The differential gear of a motor-car acts in a similar manner to the whipple-tree of a two-horse wagon, the difference being that the differential gear acts continuously in a rotary manner, while the whipple-tree acts only through a short horizontal range of movement. It may also be compared with the equalizing bars of the locomotive driving wheels.

Two forms of bevel gear differentials are shown in Figure 67. The one at the left of the drawing

FIG. 67

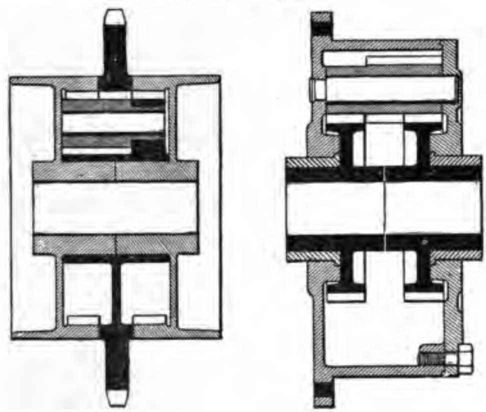


DIFFERENTIAL GEAR

has a spur gear drive, and is much used on electric cars with motors directly attached to the rear-axle. The differential at the right of the drawing has a sprocket wheel instead of a gear, through which the gear is driven.

Figure 68 illustrates two spur gear differentials. The left-hand one having an internal tooth spur gear and fixed sprocket wheel, while the right-

FIG. 68



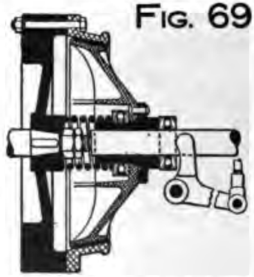
DIFFERENTIAL GEARS

hand differential has all external tooth spur gears, and may be fitted with either a sprocket wheel or a spur gear form of drive.

FRICTION-CLUTCHES. Friction-clutches are of various forms, amongst these may be mentioned those which are generally used on gasoline motor-cars; they are: The external band-clutch, the internal expanding-ring clutch, the disk or end-plate clutch and the cone-friction form of clutch.

The female member of the cone-friction clutch is usually an integral part, or attached to the rim of the motor flywheel. A form of cone-friction clutch is shown in Figure 69, in which the female member is attached to the rim of the flywheel by bolts. The driving engagement is effected by the pressure of a spring located around the extension of the flywheel shaft, and between the hub of the flywheel and that of the male member of the clutch. Disengagement of the clutch members is made by foot pressure on a pedal attached to the bell-crank lever shown to the right in the drawing.

FIG. 69



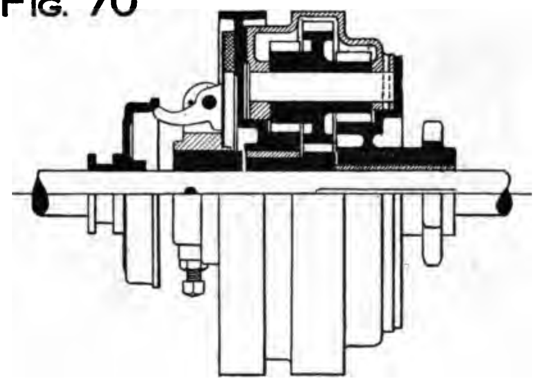
CLUTCH

SPEED-CHANGE-GEARS. The gears which effect the change of speed of motor-cars, independently of that of the motor, are of many varieties, among which may be mentioned the following: Planetary-gears, Internal-gears, Internal-clutch gears, Sliding-gears and Positive-clutch gears.

A planetary or epicyclic form of speed-change-gear is illustrated in Figure 70, which has two speeds forward and a reverse. The fast speed is

obtained by means of the disk or plate-friction clutch shown at the left in the drawing, which locks the parts of the gear together so that it

FIG. 70



PLANETARY GEAR

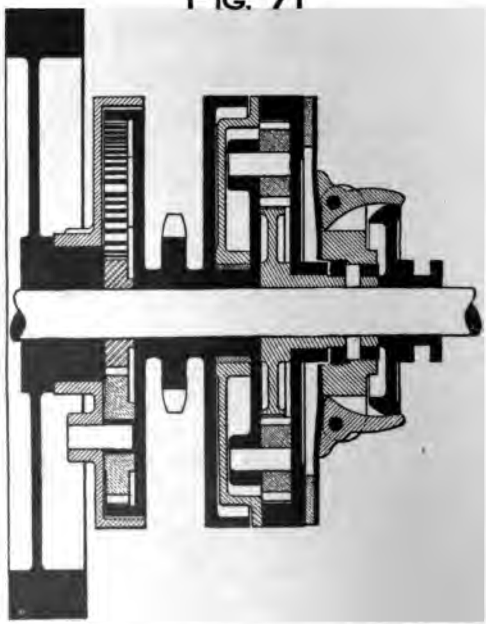
revolves with the motor shaft as a single unit. When on the slow speed the reverse gears are in action, but at a slower rate of speed than the forward motion of the device.

Figure 71 shows a form of internal planetary speed-change-gear, also having two speeds forward and a reverse. The fast speed is obtained in the same manner as the gear described in Figure 70. When the gear is running on the slow forward speed, the internal gear of the reverse is running backwards at nearly the same rate of

speed as the slow forward gear, a feature which has many objections.

A speed-change-gear having internal or individual clutches in each change-gear, is shown in

FIG. 71

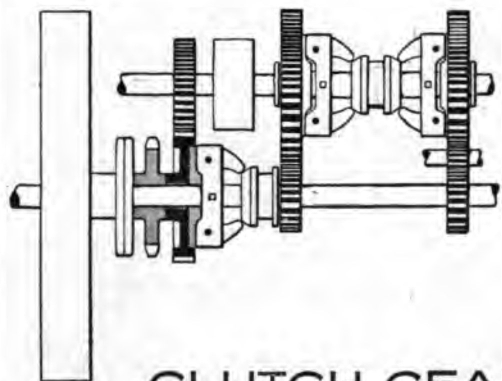


INTERNAL GEAR

Figure 72. These clutches are operated one at a time by means of the cones on the ends of the grooved collars, engaging with the dogs attached

to the male members of the clutches. The reverse is obtained by means of an idler pinion shown

FIG. 72



CLUTCH GEAR

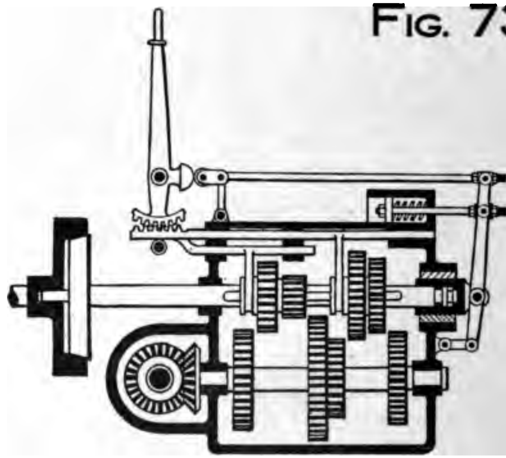
between the two gears at the right in the drawing. Figures 73 and 74 show two forms of speed-change-gears with spur teeth which slide in and out of mesh with each other, hence the term, sliding-gear. The gear shown in Figure 73 has a device by which the cone-friction-clutch is thrown out of gear, before the various pairs or sets of gears are engaged or disengaged with each other. Both speed-change-gears have three speeds forward and a reverse.

Prony Brake—See Brake Tests.

Pumps, Water Circulating. If steam is seen coming from the relief or outlet of the water circulating system, look for a blockage of the circulation or failure of the pump.

If some of the radiator tubes are cool and others are hot, look to the pump.

FIG. 73



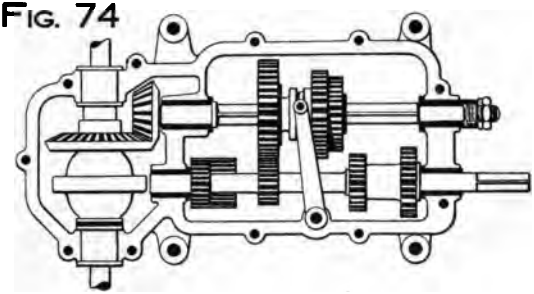
SLIDING GEAR

To test the pump before starting, run the motor for a few minutes. Then ascertain how long it takes before the top radiator tubes are thoroughly hot. If the heat of the pipes is uniform the circulation is all right.

The circulating pump is used in the belief that it affords a means for regulating the temperature

of the jacket water supply, which would not always be the case with a thermal-syphon system. Such is not the case, as the pump, being driven direct from the motor, operates at a speed which varies with the motor speed. On starting the

FIG. 74



SLIDING GEAR

motor, it pumps cold water into the jacket. It pumps slowly at slow speeds, although the motor may be taking a full charge and heating rapidly. It pumps fast at high speeds, although the wind pressure and its consequent cooling effect may be very great. If a circulating pump could be used in connection with a device to control the regulation of the motor temperature, the results would be more satisfactory.

Rotary pumps used in the water circulating system of gasoline automobile motors are of two forms, centrifugal and positive or forced-feed.

A positive or forced-feed rotary pump is shown in Figure 75. An annular ring around the pump shaft carries two blades, one of which is hinged to, and the other attached directly to the pump shaft. The outer ends of the blades are supported in the periphery of the annular ring and rotate eccentrically with it. The pump shaft is concentric with the pump chamber, but the annular ring is located eccentrically around the shaft, which drives it by means of the fixed blade on the shaft.

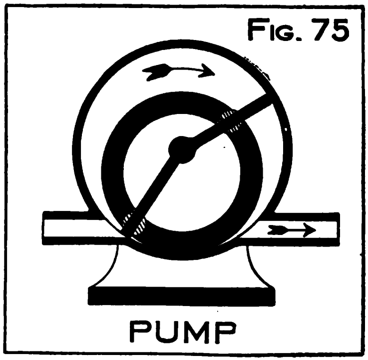


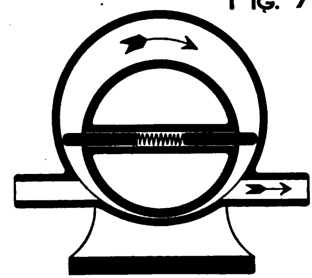
Figure 76 illustrates another form of positive-feed rotary pump, in which the pump shaft is eccentrically located in the pump chamber. A short cylinder which forms a part or portion of the pump shaft, carries two blades in a slotted opening parallel to and coincident with the axis of the pump shaft. These blades are kept in contact with the interior periphery of the pump chamber by means of coil springs, located between the blades as shown. Rotation of the cylinder in the pump chamber causes a sliding or

reciprocating action of the blades, due to the pressure of the coil springs between their inner ends.

Radiator, Combination Water Tank and—See Radiators, Water-cooling.

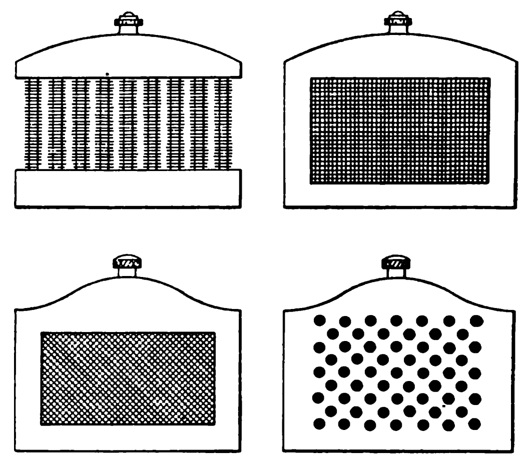
Radiators, Water-cooling. The design of a radiator should be such that the maximum of surface is exposed to the air and the greatest freedom afforded for the circulation of the water. As a circle presents the minimum surface, it would appear that a circular pipe is not the best shape for a radiator tube. There are, however, many reasons in favor of the circular section, one of which is the small resistance offered to the flow of the water. With a circular shape the minimum weight of tube is obtained for a given cubic content of liquid, and the greatest strength also for a given weight. A flattened tube section is often used, and is made up to represent in appearance the cellular radiators which have recently come into use. If the cellular radiators are well made, they have the advantage of being more

FIG. 76



PUMP

easily cleaned of mud than any other design. The number of joints forming a honey-comb radiator are likely to be a cause of leakage, and such a radiator is far more difficult to repair on the road than the tubular type with radiating fins or disks.



RADIATORS FIG. 77

Radiator, Cooling Surface per Horsepower. Motors using the thermal-syphon or natural water circulation require about 5 square feet of radiating or cooling surface per horsepower.

Radiator, Combination Water Tank and. Four styles of combination water tank and radiator are shown in Figure 77, having vertical cooling tubes with radiating disks, honey-comb or cellular

form of radiation and horizontal tubes, respectively.

Ratchet-feed Oiler—See Oilers.

Rear Axles—See Axles.

Regulation, Speed—See Governor, also Motors, Speed Regulation of Gasoline.

Relation of Spark to Mixture. The relation of the time of the spark to the mixture is best learned by experience, but most always the highest speed will be obtained when the throttle is fully open and the spark well advanced. It, however, happens on bad roads and hills that the best results are sometimes obtained by retarding the spark a little, leaving the throttle full open. With the throttle almost closed and the spark fully retarded, the motor will just run itself. Do not open the throttle suddenly, as the mixture will be more uniform if the throttle is opened gradually.

Do not advance the ignition until the motor is up to speed on the throttle. Advancing the spark suddenly, or before speed is attained with the throttle will cause pounding. Always advance the spark after the throttle is full open.

Rheostat. A rheostat is a device for regulating the flow of current in a closed electrical circuit, by introducing a series of graduated resistances into the circuit—see Electric Motors, Speed Regulation of, also Storage Battery Charging.

Road Troubles. Aside from tire troubles and accidents which may happen to a horse-drawn vehicle as well as a motor-car, any one of the following troubles may occur:

Motor misfires badly.

Motor overheats.

Motor almost stops and then starts.

One or more cylinders not firing.

Regular but unusual hissing.

Regular but unusual knocking or pounding.

Regular but unusual puffing noise.

MOTOR MISFIRES BADLY. With a single-cylinder motor this may be due to the fact that the points of the spark plug are too far apart, or that oil or soot has got on them. Misfiring in a multi-cylinder motor is caused from weak or exhausted batteries, a loose or broken wire in the ignition circuit, or a poor contact at the commutator. This applies also to a single-cylinder motor.

MOTOR OVERHEATS. A failure in the water circulation from lack of water in the tank or an obstruction in the pipes is one cause of overheating. An insufficient supply or shortage of lubricating oil is another. Too rich a mixture or too much gasoline for the quantity of air also causes overheating, especially by running slow under a heavy load.

MOTOR ALMOST STOPS AND THEN STARTS. The gasoline tank may be almost empty or the

cock in the supply pipe partially closed. The gasoline may be of low grade or stale. There may be dirt in the gasoline which has partially clogged the pipe leading to the carbureter. The union or flanged connection between the carbureter and the admission-pipe may be loose, allowing air to enter, thus preventing proper carburation of the mixture.

One or More Cylinders Not Firing. The points of the spark plugs may be too far apart; if not, they may be short-circuited by oil or soot. If the motor has individual lubrication for each cylinder, too much oil may be feeding, defiling the mixture and preventing ignition of the charge. Stop the working of the vibrators of the coils, one at a time. In this manner the cylinder which is not firing may be quickly located.

Regular but Unusual Hissing. This is due to a leak in the compression. Fill an oil can with soapy water and apply round the spark plug opening and the inlet or exhaust-valve chambers. Air bubbles will indicate the location of the leak. If the starting-crank be turned quickly the hissing noise will sometimes locate the leak.

Regular but Unusual Knocking. This sometimes is an indication that a piston or a bearing on the motor is about to seize through overheating. Advancing the ignition too far will produce the above result. A broken valve-stem, valve-spring, or a loose or worn wrist or crank-

pin bearing will also cause a knocking or pounding.

REGULAR BUT UNUSUAL PUFFING. If a puffing noise is heard which keeps time with the exhaust of the motor, but does not in any way affect the running of the motor, the connection between the motor and the main exhaust-pipe has worked loose, or there is a crack in the pipe. If the main exhaust-pipe is all right, one of the branch exhaust connections to the motor may be loose.

Roller-bearing Axles—See Axles.

Roller-chain—See Chain.

Rotary Oiler—See Oilers.

Rubber, India. All articles made of commercial rubber should be kept from contact with oil, kerosene, gasoline or grease if they are to be kept in good condition. Vulcanized rubber should not be exposed to a temperature of more than 130 degrees, Fahrenheit. Commercial or vulcanized rubber contains not to exceed 30 to 35 per cent of pure india rubber, as its stretching quality, stickiness and rapid deterioration under the action of light and air make its sole use undesirable.

Runabout. This term is applied to light gasoline or electric cars, weighing not to exceed 1,000 pounds, and with a seating capacity for two persons. Typical American gasoline and electric runabouts are illustrated in the Frontispiece.

Running Gear. A complete running gear includes the frame, springs, wheels, motor, speed-change-gear, axles and the machinery of the car except the body. The French word, chassis, is sometimes used to designate a running gear, but its use is not correct, as strictly speaking the term, chassis, applies to the frame only, or at the most to the frame and springs.

Figure 78 illustrates a vertical section of a running gear equipped with a vertical four-cylinder motor, and longitudinal propeller-shaft drive, by bevel gearing to the live rear axle.

A plan view of a running gear with double side-chain drive and rigid rear axle is shown in Figure 79. The motor is also of the vertical four-cylinder form. The water cooling system in both cases is by rotary pump, combination tank and radiator, and fan as shown.

Scratched Cylinder. The cylinder may be temporarily fixed by taking it to a first-class tinsmith and having the scratches filled with silver solder. The soldered places must be then carefully scraped flush with the bore of the cylinder. The best way is to have the cylinder re-bored and the piston-rings re-turned.

If the scratches are not too deep the cylinder can be re-bored, and a new set of piston-rings made to fit the new bore. The limit to such an increase in bore is about one-sixteenth of an inch.

Screws, Cap—See Cap Screws—Table No. 8.

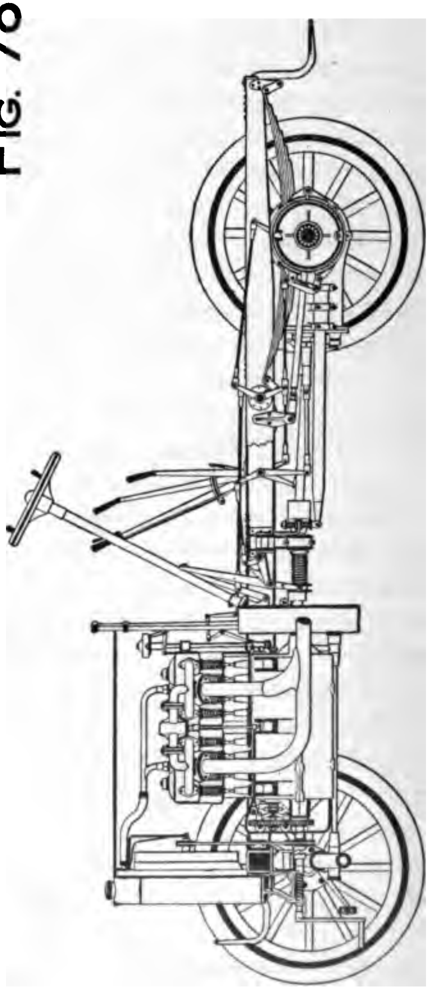


Fig. 78

RUNNING GEAR

Screw-driver, Uses of a. A screw-driver is one of the handiest and most useful tools on a car. It can be used to grind in a valve, to press a valve spring out the way, or to hold a valve spring up while the spring cap is being put on. It may also be used as a chisel to tighten a loose nut, which otherwise cannot be got at.

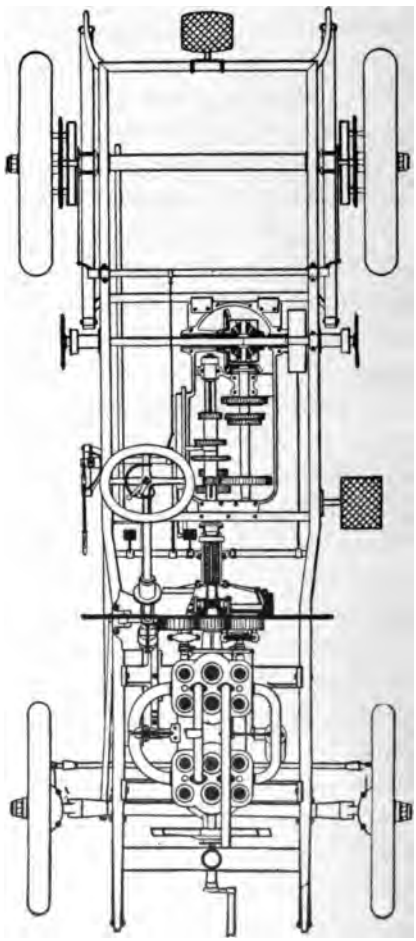
Secondary Current. The current which takes its rise in the fine wire of the induction coil, and which flows through the wire to the spark plug, is induced in the fine wire by the sudden reversal of the magnetism of the iron core.

This change of magnetism is caused by the sudden interruption of the primary current—see also Electrical Ignition and Induction Coil.

Self-firing, Causes of. If the motor should continue to run after the switch has been opened, it is due to an insufficient supply of lubricating oil, causing the motor to overheat, or to the presence of soot or some projection in the combustion chamber becoming incandescent. It may also be due to lack of water or to the water circulation working poorly, causing the motor to overheat.

Self-induction—See Electrical Ignition, also Induction Coil.

Side-slip of Motor-cars. A wheel with a weight on it when rotating bites into fresh ground as it advances. If the wheel rotate more in proportion than it advances, from any cause, it thereby loosens the particles of dirt beneath it



RUNNING GEAR Fig. 79

and loses adhesion with the ground immediately under the dirt.

The wheel can now slip sideways as easily as it can slip forwards, particularly when it has the rounded section slightly flattened, which is the case with pneumatic tires. When traveling straight ahead, and with the motor out of gear, skidding does not usually occur. A slight turn given to the steering wheel checks the speed and introduces a side pressure on both front and rear wheels, due to the machine tending to continue its path in a straight line. Generally this side pressure will not cause skidding. If, however, the motor be suddenly thrown in gear, or the brakes suddenly applied, or, what amounts to the same, a large turn is given the steering wheel, the wheels find themselves either rotating more than in proportion to their advance or advancing more than in proportion to their rotation. This immediately causes a loss of adhesion, which, once established, causes the car to skid or side-slip.

Silencer—See Muffler.

Skidding—See Side-slip of Motor-cars.

Solder. Silver solders are generally used for very fine work. They are very fusible, and non-corrosive. Hard spelter is used for steel and iron work, and soft spelter for brass work.

When copper is soldered to iron or zinc, resin should be used, or if chloride of zinc is used for a flux, the joint should be washed afterwards to

remove the acid. Unannealed wires should be soldered at as low a temperature as possible. Solder is always an alloy of other metals. It must not only be more fusible than the metal or metals to be joined, but it must have some chemical affinity for them. Different kinds of solder are therefore employed for different purposes. It is called either hard or soft, according to its fusing point.

Solders and Spelters for use with different metals, and their proportional parts by weight are

Solder for:	
Electrician's use	1—Tin, 1—Lead.
Gold	24—Gold, 2—Silver, 1—Copper.
Platinum	1—Copper, 3—Silver.
Plumber's—Hard	1—Lead, 2—Tin.
Soft	3—Lead, 1—Tin.
Silver—Hard	1—Copper, 4—Silver.
Soft	1—Brass, 2—Silver.
Tin—Hard	2—Tin, 1—Lead.
Soft	1—Tin, 1—Lead.
Spelter for:	
Fine brass work	8—Copper, 8—Zinc, 1—Silver.
Common brass	1—Copper, 1—Zinc.
Cast iron	4—Copper, 3—Zinc.
Steel	3—Copper, 1—Zinc.
Wrought iron	2—Copper, 1—Zinc.

Spark Coil—See Electrical Ignition, also Induction Coil.

Spark Gap, Extra. An extra spark gap in the secondary circuit will cause a spark to jump across the points of a fouled plug because the intensity of the voltage of the current is reduced to such an extent that the current will jump across the points in preference to the path of

higher resistance formed by the carbon deposit upon the insulation of the spark plug. As the spark plug and the spark gap are in series with each other, it follows that with a single gap—the spark plug alone—the tension of the secondary circuit is about 30,000 volts, while with two gaps the tension at each gap will be only about 15,000 volts. That this statement is true may be shown by an arc light circuit of 500 volts, with five 100-volt lamps in series with each other in the circuit, and which have a potential of 100 volts each, and not 500 volts, as might be supposed. This explanation, therefore, destroys the claim that the use of the extra gap intensifies the arc or spark at the points of the plug. The real advantage of the extra gap is that the reduction of the voltage, instead of its increase, reduces the tendency of the current to arc across the carbon deposit.

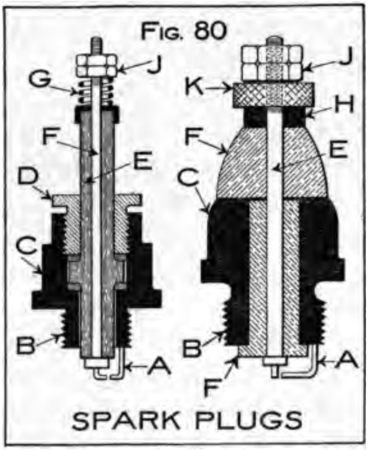
The extra spark gap will only be found effective so long as the carbon deposit upon the insulation of the spark plug is small, or mixed with oil, which increases the resistance of this path. The arcing will continue at the point of the plug until the carbon deposit is rich enough to form a path for the entire volume of the current, when the plug will cease sparking—but the extra spark gap will continue to arc. One advantage of the extra spark gap is that it provides a means of seeing whether the secondary circuit is in working order without removing the plug

from the cylinder, and the device should be ‹ nected in the circuit by a two-point switcl enable it to be thrown in and out of the secon‹ circuit. The use of the extra spark gap never absolutely remove the necessity for kee] the insulation of the spark plug in good condi and free from soot or oil. As long as batteries are strong enough to maintain the voltage of the primary circuit, just so long the extra spark gap work successfully in secondary circuit, and when the electromo force of the batteries falls below the nor point, it will be found necessary to cut out extra spark gap, to maintain an efficient sparl the combustion chamber of the motor.

Spark Intensifier—See Spark Gap, Extra

Spark Plugs. The trouble with motors ı firing, is generally due to dirty spark plugs. 1 is caused by using too much cylinder oil, whi when subjected to the intense heat in cylinder, turns to carbon. This carbon depo on the insulated porcelain and the body of plug, and instead of the current jumping fı the point in the body to the point in the porcel and making a spark, it follows the easiest pa which is the carbon, and does not make a sp at the plug points at all. When this occurs motor will misfire. The first thing to do w a motor misfires is to test the spark plug. T the motor until the battery circuit is clo

Unscrew the spark plug from the motor, then re-connect the wire to it just the same as it was before. Lay the metal part of the plug body on the flywheel or some other unpainted part of the motor, being careful that the metal part of the plug body only touches the motor and that the porcelain part is clear. If the spark jumps in short jerks between the inner end of the porcelain and the interior of the plug body it is sooted and needs cleaning. If it jumps at the points as it should do, the trouble is elsewhere; probably at the battery, loose connecting wires, or the vibrator of the coil is not properly adjusted.



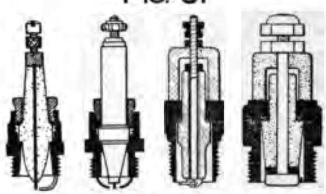
A—Platinum point.
B—Thread.
C—Plug body.
D—Bushing.
E—Insulated terminal.
F—Porcelain bushing.
G—Expansion spring.
H—Asbestos washer.
J—Lock nuts.
K—Assembly nut.

To clean a spark plug properly use a 50 per cent solution of hydrochloric (muriatic) acid,

washing the points of the plug with a tooth brush, occasionally dipping the plug into the acid. After cleaning the spark plug in this manner rinse it in water.

Spark Plugs, Construction of. Two spark plugs are shown in Figure 80, which, while differing radically in their construction, effect the same purpose, that of producing a spark or arc in the combustion chamber of the motor. The accompanying table and reference to Figure 80, will fully explain the construction of the spark plugs.

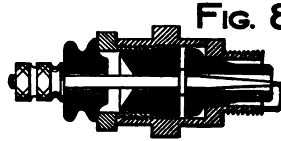
FIG. 81



SPARK PLUGS

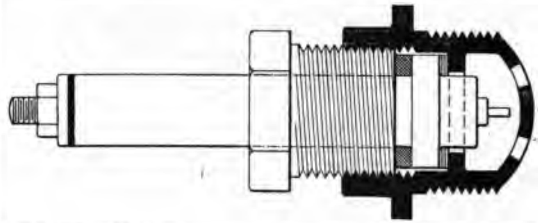
Cross-sections of four different forms of spark plugs are shown in Figure 81. All are constructed with a view to make the outside or extraneous path caused by sooting, as long as possible, so as to prevent if possible short-circuiting of the plug from this cause.

FIG. 82



SPARK PLUG

Figure 82 shows a form of spark plug in which two extra air-spaces are provided,



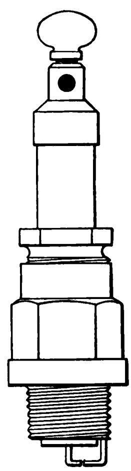
SPARK PLUG FIG. 83

one between the center rod or terminal and the porcelain bushing, and the other between the porcelain bushing and the shell or body of the plug.

The spark plug shown in Figure 83 has a closed chamber around and over the center insulated rod or terminal, this chamber is a part of the body of the plug and forms the other terminal of the plug. It acts as a small combustion chamber and streams of fire are supposed to be thrown from the small openings in the chamber, when the arc or spark occurs therein.

An exterior view of a form of spark plug in general use is shown in Figure 84.

FIG. 84



SPARK PLUG

Spark plugs of American manufacture are made with three different sizes of threads: One-half inch pipe-size, the actual outside diameter of which is 84-100 of an inch, with 14 threads per inch. Three-quarters of an inch diameter, with 18 threads per inch, and 7-10 of an inch diameter, with 17 threads per inch. The last named one is the French or Metric standard thread.

Specific Gravity. In the absence of a proper instrument, the specific gravity of gasoline or any other liquid may be obtained as follows:

Weigh a certain quantity of distilled water at 4 degrees Centigrade, or 39½ degrees Fahrenheit.

Weigh the same quantity of gasoline or other liquid under test.

Divide the weight of the liquid by the weight of the water, and this will give the required specific gravity of the liquid.

The specific gravities of various liquids are as follows:

Alcohol at 15° C.	0.794
Acid, nitric	1.217
Acid, sulphuric	1.841
Ether at 15° C.	0.720
Naphtha	0.848
Oil, linseed	0.94
Petroleum	0.878
Gasoline at 15° C.	0.680 to 0.720
Water, sea, at 4°	1.026
Water, pure, at 4°	1.0

Speed-change Gear—See Power Transmission Devices.

Speed, Cyclic Variation of. The cyclic irregularity of any reciprocating-piston motor is

defined as the ratio of the difference between the maximum and minimum velocity in any one revolution to the mean velocity. The great difficulty in measuring this ratio is the continual variation in the mean velocity. One system of measurement uses a tuning-fork, which traces a wavy line on a smoked cylinder attached to the motor shaft. Another apparatus consists of a disk attached to the motor shaft, and a flywheel turning freely on the same axis. The disk and flywheel are geared together by a planetary gearing, whose axis, perpendicular to that of the flywheel, carries a pencil point tracing on a rotating drum. The flywheel is turned through the planetary gearing, and takes up the mean speed of the motor. As it is too heavy to follow the cyclic variations in speed of the disk, these cause the axis of the planetary gearing to move backward and forward round the axis of the disk, and the pencil point therefore traces a periodic curve on the drum. This curve, however, does not give the difference in velocity, but the relative change in position of the disk and flywheel, and the maximum difference in velocity must be calculated from the two steepest tangents to the curve. This apparatus is troublesome in the calculation of results and is not sufficiently sensitive for small irregularities. An apparatus constructed on the principle of the von Alteneck transmission dynamometer is also used for this

purpose, a pulley attached to the motor shaft being connected by a belt to a flywheel, which takes up the mean velocity of the motor; the variations in velocity produce variations in the tension on the two sides of the belt, and an index is arranged to measure these. The elasticity of the belt renders this apparatus unsuitable for any absolute measurements. Another device consists of a heavy cylinder, mounted on an axis fixed to the motor shaft by ball-bearings; the friction in these causes it to take up the mean velocity. A frame fixed to the shaft embraces the cylinder, and carries a pencil point which is free to move along the cylinder. A string attached to the pencil passes over a pulley to a sleeve running free on the axis; if this be held still, the string winds up on it, and pulls the pencil along the cylinder. As the motion of the cylinder is uniform, while the pencil follows the irregularities of the motor, the latter traces a curve, from which the cyclic irregularity can be reckoned. This apparatus was found to work well, but was not sufficiently sensitive for small irregularities.

The only method which has been found capable of measuring a very small irregularity is to employ a small independently excited dynamo driven by the motor, and take its curve of volts by means of a Joubert contact-maker and potentiometer. As the volts are proportional to the speed, this gives also the curve of speed of the

motor. If there be no irregularities in the dynamo voltage due to its construction, this method is capable of giving very accurate results, but it is troublesome and unsuited for practical work.

Speed in Miles per Hour. The following table gives the speed in miles per hour, from 27.69 to 120 miles per hour, for a mile covered in any given interval of time in minutes and seconds, between 2:10 and 0:30.

SPEED IN MILES PER HOUR.

Time in Minutes and Seconds.	Speed in Miles per Hour.	Time in Minutes and Seconds.	Speed in Miles per Hour.	Time in Minutes and Seconds.	Speed in Miles per Hour.	Time in Seconds.	Speed in Miles per Hour.
2:10	27.69	1:38	36.73	1:15	48.00	52	69.23
2:05	28.80	1:37	37.11	1:14	48.65	51	70.58
2:00	30.00	1:36	37.50	1:13	49.32	50	72.00
1:59	30.25	1:35	37.89	1:12	50.00	49	73.47
1:58	30.51	1:34	38.29	1:11	50.70	48	75.00
1:57	30.77	1:33	38.71	1:10	51.43	47	76.59
1:56	31.03	1:32	39.13	1:09	52.17	46	78.26
1:55	31.30	1:31	39.56	1:08	52.94	45	80.00
1:54	31.58	1:30	40.00	1:07	53.73	44	81.82
1:53	31.86	1:29	40.45	1:06	54.54	43	83.72
1:52	32.14	1:28	40.91	1:05	55.38	42	85.71
1:51	32.43	1:27	41.38	1:04	56.25	41	87.80
1:50	32.73						
1:49	33.03	1:26	41.86	1:03	57.14	40	90.00
1:48	33.33	1:25	42.35	1:02	58.06	39	92.31
1:47	33.64	1:24	42.86	1:01	59.02	38	94.74
1:46	33.96	1:23	43.37	1:00	60.00	37	97.29
1:45	34.28	1:22	43.90	59	61.02	36	100.00
1:44	34.62	1:21	44.44	58	62.07	35	102.86
1:43	34.95	1:20	45.00	57	63.16	34	105.88
1:42	35.29	1:19	45.57	56	64.28	33	109.09
1:41	35.64	1:18	46.15	55	65.45	32	112.50
1:40	36.00	1:17	46.75	54	66.67	31	116.63
1:39	36.36	1:16	47.37	53	67.92	30	120.00

Speed of Gasoline Motors. In explosive motors the products of combustion diminish in about the ratio of the increase of speed. The pressures and temperatures at admission and exhaust are variable, and depend on the speed and the mean temperature of the cylinder wall. The compression pressure decreases in proportion to the increase of speed, owing to the diminished volume of mixture at higher speeds. If it were not for this the power of a motor of given bore and stroke would go up in the same proportion as the speed.

An automobile motor differs fundamentally from the stationary form by reason of its being required to run at variable speeds. If the valves are well designed, nearly the full volume of gas should be taken in at higher speeds and the compression will actually improve at higher speeds owing to the diminished time for leakage round the piston-rings. This tends to improve the fuel economy of the motor.

Speed of Wheels—See Table No. 20.

Speed Regulation of Motors—See Motors, Speed Regulation of Gasoline, also Electric Motors, Speed Regulation of.

Spontaneous Ignition—See Self-firing.

Springs. The length and number of leaves in the springs of motor cars of similar weight and power vary, and without any reason for so doing. The general use of pneumatic tires hides many

imperfections in this respect as well as in others. Springs of insufficient strength are a source of great danger, and frequent examination should be given to them. Springs are not necessarily of insufficient strength because they appear to be light. Short springs are not desirable, as they are more liable to break than a longer spring, the deflection per unit of length being greater. Stiffness in short springs is usually avoided by lightness, which is likely to lead to breakage, especially when the hole for the bolt through the center of the spring is made larger than necessary.

TABLE NO. 20.

REVOLUTIONS PER MINUTE OF WHEELS FOR VARYING SPEEDS.

Diameter of wheel in inches.	Miles per hour.									
	2	4	6	8	10	15	20	25	30	40
24	28	56	84	112	140	210	280	350	420	560
26	26	52	78	103	129	194	258	323	388	517
28	24	48	72	96	120	180	240	300	360	480
30	22	45	67	90	112	168	224	280	336	448
33	20	41	61	82	102	153	204	255	306	408
36	19	37	56	75	93	140	187	234	280	374
42	16	32	48	64	80	120	160	200	240	320

Springs, Dimensions of. In calculating the dimensions and elastic limit of springs for motor-car use, the elastic limit must be carefully considered with regard to the dead and maximum loads to be carried by the car. The dead load

is the weight of the car when at rest. The maximum load is the greatest weight that can possibly be carried with good spring action. The springs to retain their elasticity should have their ultimate strength far beyond their maximum load capacity.

Springs, Suspension of. Apart from certain figures on the dead weight of the load and the proper size and tensile strength of the springs, there is no information regarding the proper method of hanging the springs for motor-cars. This must continue to be governed largely by experiment, since the usual construction of motor-cars, renders necessary the use of devices known as distance rods, to maintain a fixed distance between the motor and the rear axle, as the deflection of the springs would otherwise permit it to be disturbed. The usual method of construction is to set the springs lengthwise of the car, as in this manner most of the violent jars are absorbed, and the fixed relation of the motor and the rear axle are maintained, without rigid connections.

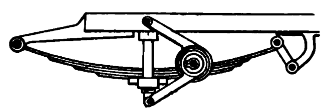


FIG. 85

Spring-buffer. A cushioning device, intended to eliminate or remove the bouncing action of the springs of a motor-car, when passing over humps

or depressions in the road surface at a high rate of speed, is illustrated in Figure 85. A flat coiled spring is attached to arms or links, one of which is hinged to the center of the spring and the other to the frame of the car.

Spring-hangers—See Body-hangers.

Sprockets. The circular instead of the linear pitch is often erroneously used in calculating the pitch diameter of a sprocket wheel. Reference to

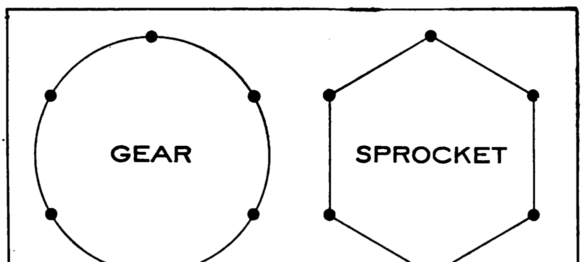


FIG. 86

Figure 86 will illustrate the difference between circular and linear pitch, and help to demonstrate the case more clearly. The view at the left of the drawing shows the circular pitch and the view at the right the linear pitch of a gear or sprocket wheel respectively. If the circular pitch of the gear be one inch and the gear has six teeth as shown, the pitch diameter will be 6×0.3183, which gives 1.91 inches as the pitch diameter. Let the linear pitch of the sprocket be

also one inch, and with six teeth as before. In a sprocket having 6 teeth, the radius is equal to the linear pitch, as the figure is composed of six equilateral triangles, and the pitch diameter of the sprocket wheel is consequently 2 inches.

Sprockets, Dimensions of. Table No. 21 gives the pitch diameters of sprockets for roller chain of 1 inch, $1\frac{1}{4}$ inch and $1\frac{1}{2}$ inch pitch, with 7 to 28 teeth. The outside diameters may be found by adding the diameter of the roller to the pitch diameter of the sprocket—see Chain.

TABLE No. 21.

DIMENSIONS OF SPROCKETS FOR ROLLER CHAIN.

Number of Teeth in Sprocket.	1 Inch Pitch.	1¼ Inch Pitch.	1½ Inch Pitch.
	Pitch Dia.	Pitch Dia.	Pitch Dia.
7	2.31	2.88	3.46
8	2.61	3.27	3.92
9	2.92	3.65	4.38
10	3.24	4.04	4.85
11	3.54	4.44	5.33
12	3.86	4.83	5.79
13	4.18	5.22	6.27
14	4.50	5.62	6.75
15	4.81	6.01	7.22
16	5.12	6.41	7.69
18	5.76	7.21	8.64
20	6.39	7.99	9.59
22	7.03	8.79	10.55
24	7.66	9.58	11.49
26	8.31	10.38	12.44
28	8.95	11.19	13.42

Squares of Numbers—See Table.

SQUARES OF NUMBERS FROM 1 TO $8\frac{7}{8}$, ADVANCING BY $\frac{1}{8}$ OF ONE INCH.

Number.	Square.	Number.	Square.	Number.	Square.	Number.	Square.
1	1.000	3	9.000	5	25.000	7	49.000
$1\frac{1}{8}$	1.266	$3\frac{1}{8}$	8.766	$5\frac{1}{8}$	26.266	$7\frac{1}{8}$	50.766
$1\frac{1}{4}$	1.563	$3\frac{1}{4}$	10.563	$5\frac{1}{4}$	27.563	$7\frac{1}{4}$	52.563
$1\frac{3}{8}$	1.891	$3\frac{3}{8}$	11.391	$5\frac{3}{8}$	28.891	$7\frac{3}{8}$	54.391
$1\frac{1}{2}$	2.250	$3\frac{1}{2}$	12.250	$5\frac{1}{2}$	30.250	$7\frac{1}{2}$	56.250
$1\frac{5}{8}$	2.641	$3\frac{5}{8}$	13.141	$5\frac{5}{8}$	31.641	$7\frac{5}{8}$	58.141
$1\frac{3}{4}$	3.063	$3\frac{3}{4}$	14.003	$5\frac{3}{4}$	33.063	$7\frac{3}{4}$	60.063
$1\frac{7}{8}$	3.516	$3\frac{7}{8}$	15.016	$5\frac{7}{8}$	34.516	$7\frac{7}{8}$	62.016
2	4.000	4	16.000	6	36.000	8	64.000
$2\frac{1}{8}$	4.516	$4\frac{1}{8}$	17.016	$6\frac{1}{8}$	37.516	$8\frac{1}{8}$	66.016
$2\frac{1}{4}$	5.063	$4\frac{1}{4}$	18.063	$6\frac{1}{4}$	39.063	$8\frac{1}{4}$	68.063
$2\frac{3}{8}$	5.641	$4\frac{3}{8}$	19.141	$6\frac{3}{8}$	40.641	$8\frac{3}{8}$	70.141
$2\frac{1}{2}$	6.250	$4\frac{1}{2}$	20.250	$6\frac{1}{2}$	42.250	$8\frac{1}{2}$	72.250
$2\frac{5}{8}$	6.891	$4\frac{5}{8}$	21.391	$6\frac{5}{8}$	43.891	$8\frac{5}{8}$	74.391
$2\frac{3}{4}$	7.563	$4\frac{3}{4}$	22.563	$6\frac{3}{4}$	45.563	$8\frac{3}{4}$	76.563
$2\frac{7}{8}$	8.266	$4\frac{7}{8}$	23.766	$6\frac{7}{8}$	47.266	$8\frac{7}{8}$	78.766

Starting a Motor. The most important point about starting a gasoline motor is to ascertain if the cock in the supply pipe leading from the gasoline tank is open. Failure to do this has caused the display of more temper, profanity and anxiety than any other detail, except that of forgetting to close the switch before cranking the motor. Another point is to see that the tank has been previously filled with gasoline.

Next flush the carbureter to see if the gasoline flows from the tank, then give the motor one or two turns by means of the starting-crank and

with the compression-release cock—if any—open. If a mechanical feed or splash lubrication is used, there will be no necessity to look after the lubrication, but if a gravity oil feed is used, do not forget to turn on the oil before starting the motor.

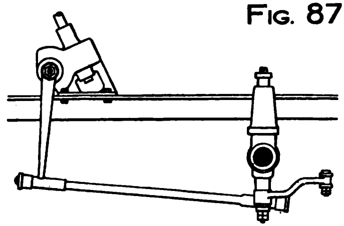
Never forget to retard the ignition before starting the motor. A back fire will result if this precaution is neglected, and a nasty blow, or even a broken wrist or arm may be the result. The proper way to avoid this trouble is to have the ignition lever spring-controlled so that the ignition is always retarded when the motor is not running.

Starting Troubles. If the motor refuses to start, the trouble may be due to oil or grease on the spark plug points; this may be remedied without removing the plug, by disconnecting the secondary wire from the plug and placing it near the terminal, so as to allow an external and visible spark to occur. Once the motor is started the oil gets burned up by the heat, so that ignition will continue after a permanent connection of the secondary wire has been made. Generally it is necessary to stop the motor, or at least the spark, to facilitate re-connecting the wire without receiving a shock, but if the motor is hot it will re-start easily. This is merely a temporary adoption of the extra spark gap.

Sometimes the motor will start readily, but dense smoke having a strong odor will issue from the muffler. This may be an indication that the mixture is too rich, although it is frequently due to an excess of lubricating oil in the cylinder. To correct the mixture, more air should be admitted to the carbureter.

Failure of the motor to start is more often occasioned by too weak than by too rich a mixture. The first thing to do, if regulating the air does not correct it, is to ascertain if the gasoline pipe is free from obstruction. This pipe is not large, and is more or less crooked. A partial stoppage of the pipe will therefore result in a too weak mixture.

FIG. 87

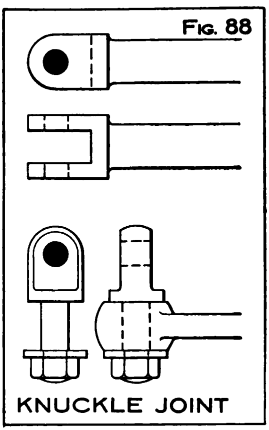


STEERING GEAR

Water in the carbureter is not an infrequent cause of the motor failing to start. All gasoline contains more or less water, which, being heavier than the gasoline, settles to the bottom of the supply tank and finds its way to the carbureter. If the pet-cock at the bottom of the carbureter be opened, the water—which will have collected in the lowest part of the carbureter—will pass out with the gasoline.

Steering Connections. The method of connecting the steering arm of a wheel-steering device to the steering lever attached to the knuckle of one of the steering wheels of the car is shown in Figure 87. The ends of the steering rod are provided with ball and socket joints. The complete mechanism as shown is usually known as the steering-gear—see Ball and Socket Joints, also Steering Devices.

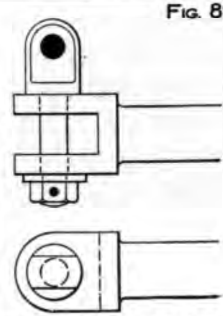
Swivel or knuckle-joints for connecting the steering arm of the wheel or lever steering mechanism to the arms on the knuckle-joints of the steering wheels are of various forms. Figures 88 and 89 show knuckle-joints which may be used for the above purpose. They are of simple construction and practically inexpensive to make. They may be used with any standard drop-forged jaw-ends.



Steering Devices. Steering devices are of three types: **Lever, Side-bar** and **Wheel-steering.** The first two are used on some light gasoline and electric runabouts, but wheel-steering in one of its many forms seems to predominate. Wheel-steering is

effected in four different ways, which are: Worm and gear—Screw and nut—Pinion and rack, and Pinion and quadrant. The first two forms are irreversible, that is, the front or steering-wheels of the car cannot by any chance move the hand-wheel, due to the locking action of the devices. The last two are reversible, but on account of the great reduction in motion between the hand-wheel and the steering-wheels of the car, a considerable effort would be required to move the hand-wheel from the other end.

FIG. 89



KNUCKLE JOINT

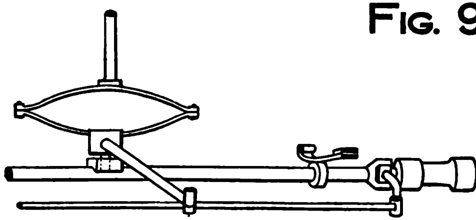
Figure 90 illustrates a lever-steering device, with a compensating spring between the steering lever and the connecting rod attached to the steering-wheels of the car. The compensating spring is supposed to eliminate all shocks or jars, due to inequalities of the road.

A worm and gear, or irreversible form of steering mechanism is illustrated in Figure 91. It is usually enclosed and the case filled with heavy oil or grease.

The only objection to the worm and gear lies in the fact that after continued use, the wear between the worm and gear quadrant occasions back-lash in the steering arm attached to the

quadrant. The screw and split or adjustable nut, although a more expensive construction, has

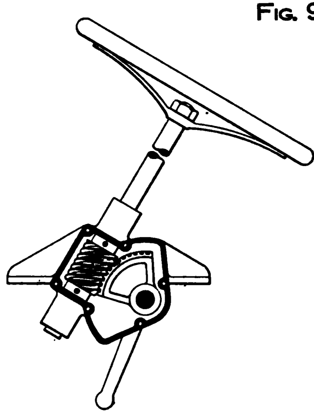
Fig. 90



STEERING DEVICE

decided advantages over the worm and gear device in this respect, as all back-lash due to wear may be readily taken up.

Fig. 91



WORM GEAR

Steering-gear—See Steering Connections.

Steering-knuckles — See Axles.

Stopping a Motor. The first things to do after stopping the motor are:

Shut off the battery switch, and remove the plug.

Close all oil cups or lubricators.

Shut off gasoline if there is no float in the carbureter.

In the winter and if the car will be in a cold place, drain off the water from the circulating system.

Wipe off the motor, and see that it is ready for the next run.

When cleaning the motor examine all bolts and nuts, and all points needing adjustment.

Note the condition of the journals and bearings, if they are hot ascertain the cause of heating.

Storage Batteries. In order that electrical energy may be taken from a storage battery, a current of electricity must first be passed through the battery. A chemical action takes place on the active material of the plates in the cells. During the discharge a reverse chemical action takes place and the plates resume their former condition. Thus it is apparent that a storage battery, if properly made, can be used over and over again, without materially impairing its condition. On account of the chemical changes involved, the whole of the energy required to charge a battery is not available as useful current. Consequently, in determining the size of battery to be used, its efficiency at various rates of charge and discharge must be taken into consideration.

Battery Capacity. The capacity of a battery

depends on the number and size of the plates composing the elements of the cell. Increasing the number of plates increases the capacity, but does not increase the voltage of the cell.

The capacity of a battery is expressed in ampere-hours. As an example, a particular cell will, on discharge, give twenty-five amperes for eight hours, or it has a total capacity of 200 ampere-hours, when discharged at its normal rate of eight hours. If discharged at a higher rate, say five or three hours, the total capacity will be considerably less. For example, the above cell will discharge at the rate of thirty-five amperes for five hours, giving a total capacity of 175 ampere-hours, or it will discharge at the rate of fifty amperes for three hours, giving a total capacity of 150 ampere-hours.

WATT-HOUR CAPACITY. The watt-hour capacity of a battery depends on the density of the electrolyte used. Up to a certain point, the higher the specific gravity of the electrolyte used, the greater will be the capacity. Care should be exercised not to permit the batteries to be discharged too low, or to remain idle for any considerable length of time without being thoroughly re-charged.

ELECTROLYTE. The electrolyte used in a storage battery is made up of three to four parts of water to one part pure sulphuric acid. Nothing except distilled water should be used. Freshly

caught rain water may be used in case distilled water cannot be obtained. Although it is considerably cheaper, never use commercial sulphuric acid, as it will ruin a battery in a short time, due to the presence of iron in the commercial acid. Chemically pure acid only should be used.

SPECIFIC GRAVITY. The electrolyte should have a specific gravity of 1.25, this is usually written as 1250. The specific gravity of a solution is determined by the use of a hydrometer, which is an instrument so designed that the zero of its scale is on a level with the surface, when immersed in pure or distilled water. The hydrometer will rise until the 25 degree mark is about on a level with the surface, when sufficient acid has been added to raise the specific gravity to 1250. The electrolyte should always cover the top of the plates at least one-half of an inch, and, when fully charged, should be tested every few weeks with the hydrometer.

VOLTAGE. A storage battery has a normal electromotive force of about two volts and an internal resistance so low as to be negligible in all ordinary calculations, consequently the voltage across the terminals of a number of storage cells in series will be equal to the combined voltage of the individual cells and will in most cases remain practically the same, irrespective of the quantity of current which is flowing from the battery.

A storage battery will work equally well on either an open or closed circuit, it will give out a small or large current continuously or intermittently, and under practically the same voltage.

CHARGING. The voltage of the charging circuit should be at least 20 per cent higher than the voltage of the storage battery. Always use a direct current, as an alternating current cannot be used. If possible, a storage battery should always be charged at its normal charging rate, or preferably at a slower rate, for the slower a storage battery is charged, the greater will be its discharge capacity. The normal charging rate is usually taken to be four to five hours, irrespective of the capacity of the battery. Charge the battery until the voltmeter shows 2.6 volts while the battery is in the charging circuit.

CHARGING CONNECTIONS. When charging a storage battery, it is of great importance that the connections with the charging circuit be properly arranged. That is, the positive pole of the circuit should always be connected to the positive pole of the storage battery.

QUICK CHARGING. Sometimes it is desirable to charge a battery quickly, in order to save time, when far from home with an electric car whose batteries are almost exhausted. As a general rule, such a procedure should not be adopted unless the storage battery is practically

discharged, and then only when in the hands of an expert.

DISCHARGING. In driving an electric car the battery should be nursed as much as possible, on steep hills and rough roads. If the amperage rises abnormally when going up a steep hill it is better to tack from side to side than to go straight up the hill.

If the voltmeter shows a fall below 1.75 per cell, it does not necessarily indicate that the battery is exhausted or injured. The car should be stopped for a few minutes, when the normal voltage will again be shown. If this occurs often, however, the battery should be examined by an expert.

Storage Batteries, Care of. On receiving batteries unpack the cases carefully, opening them from the marked side. Clean off all excelsior or dirt that may have collected on the cells or trays.

Examine each connection carefully to see that none have been broken through rough handling in transit. If any are broken have a tinsmith solder the connection firmly, or when possible, have a lead-burned connection made.

Unscrew the stopper of each cell and see that the electrolyte covers the tops of the plates in each cell from one-half to one inch. If it does not more electrolyte should be added.

The electrolyte is made by mixing chemically pure sulphuric acid with distilled water until

the specific gravity, when the liquid is cold, is about 1250.

The proportion of acid to water is about one part of the former to three and one-half parts of water.

Always add the acid to the water, **not water to the acid**. Heat is always evolved in adding acid to water and the electrolyte should always be allowed to thoroughly cool before adding it to cells.

Always use distilled or rain water, as other water is liable to contain iron or other salts injurious to plates.

Do not use distilled water from an ice plant, as it is almost sure to contain ammonia. The presence of the following substances in the electrolyte tends to destroy the plates: Chlorine, iron, copper, and the nitrates.

If any of the rubber cells have been broken or cracked in transit remove the cell from the tray at once, cutting its connection with the other cells, and order a new one in its place.

It may be determined whether a cell is leaking by adding more electrolyte, if it is found to be below the tops of the plates. After adding the electrolyte until the tops of the plates are covered, if in a short time the electrolyte is found to be lowering or below the plates again, the cell is imperfect.

CHARGING. Always have the batteries exposed to a free circulation of air when charging, remov-

ing the stoppers or vents to allow of the free escape of the gases.

Charge the battery at the normal rate specified until the electrolyte boils in the cells and the voltmeter indicates that each cell is giving 2.6 volts while the current is passing through the charging circuit. If the cells get hot reduce the charging rate one-half.

DISCHARGING. In order to obtain the best results the battery should never be allowed to be discharged to a voltage lower than 1.75 and if possible it should be stopped at 1.8 volts per cell.

Table No. 22 gives the weight, general dimensions and discharge rate for storage batteries of from 45 to 145 ampere-hour capacity.

TABLE NO. 22.

Weight in Pounds.	Outside Dimensions.			Discharge in Hours.			
	Inches Width.	Inches Length.	Inches Height.	10 Amp.	15 Amp.	20 Amp.	25 Amp.
9	$5\frac{3}{8}$	$1\frac{3}{8}$	$10\frac{1}{2}$	$4\frac{1}{2}$	...	...	...
12	$5\frac{3}{8}$	2	$10\frac{1}{2}$	$7\frac{1}{2}$	$4\frac{3}{4}$	$3\frac{1}{2}$	...
15	$5\frac{3}{8}$	$2\frac{5}{8}$	$10\frac{1}{2}$	$9\frac{3}{4}$	$6\frac{1}{2}$	$4\frac{5}{8}$	$3\frac{5}{8}$
19	$5\frac{3}{8}$	$3\frac{1}{4}$	$10\frac{1}{2}$	$12\frac{1}{2}$	$8\frac{1}{4}$	6	$4\frac{5}{8}$
22	$5\frac{3}{8}$	$3\frac{7}{8}$	$10\frac{1}{2}$	$14\frac{3}{4}$	$9\frac{3}{4}$	$7\frac{1}{4}$	$5\frac{5}{8}$
26	$5\frac{3}{8}$	$4\frac{1}{2}$	$10\frac{1}{2}$	$17\frac{1}{2}$	$11\frac{1}{2}$	$8\frac{1}{2}$	$6\frac{5}{8}$
29	$5\frac{3}{8}$	$5\frac{1}{8}$	$10\frac{1}{2}$	$19\frac{3}{4}$	$13\frac{1}{4}$	$9\frac{3}{4}$	$7\frac{5}{8}$
35	$5\frac{3}{8}$	$6\frac{1}{8}$	$10\frac{1}{2}$	25	$16\frac{5}{8}$	$12\frac{1}{2}$	10
24	$6\frac{1}{4}$	$3\frac{1}{4}$	$10\frac{1}{2}$	$14\frac{3}{4}$	$9\frac{3}{4}$	$7\frac{1}{4}$	$5\frac{5}{8}$

Storage Battery Charging. When charging a storage battery the strength of the charging

current should always be in proportion to the ampere-hour capacity of the battery.

The voltage of the charging circuit should be at least 20 per cent higher than the maximum voltage of the battery when fully charged.

When a storage battery is fully charged it should show 2.6 volts per cell, and the fact that the battery is fully charged will be indicated by an apparent boiling of the liquid and a free discharge of gases from the cells.

When charging storage batteries, great care should be taken to have the doors of the body open, as while charging a great deal of hydrogen gas is thrown off, and no spark, lighted match or naked flame of any kind should be brought near the car during the process of charging.

When charging at high rates, great care should be taken not to heat the cells. If at any time the cells show a tendency to heat while charging, the charging current should be immediately reduced.

If at any time the batteries will not retain their charge after being fully charged, it is an indication that they are short-circuited. This is due to sediment settling so rapidly in the bottom of the cell that it touches the bottom of the plates in the cells. Nothing will tend to destroy a battery quicker than to try to operate it in the above conditien, and whenever a battery shows an indication of not holding its charge, or falling far

below its normal capacity, it should be inspected without loss of time.

Do not attempt to charge the battery at a high rate unless it is completely discharged, as the rate of charge that the battery will take is dependent upon the amount of energy already absorbed by the battery.

When charging a battery at a high rate, understand as near as possible the condition of the battery, as the high rate should only be used when the battery is completely discharged.

Always charge the battery promptly after using the car. Nothing will depreciate the battery capacity so much as to leave it standing discharged for some length of time, except using the batteries without the proper amount of solution in them. The solution should at all times extend above the top of the plates.

The charging circuit should always be supplied with a volt meter, ampere meter and rheostat. In this way the voltage of the battery can always be measured, or the amount of current it is desired to put into the batteries, can be measured by the ampere meter and the amount varied as desired by the use of the rheostat or resistance.

The cost of a charging outfit depends upon the size and capacity of the battery to be charged. One charging outfit is capable of charging one car several times a day or several cars a day.

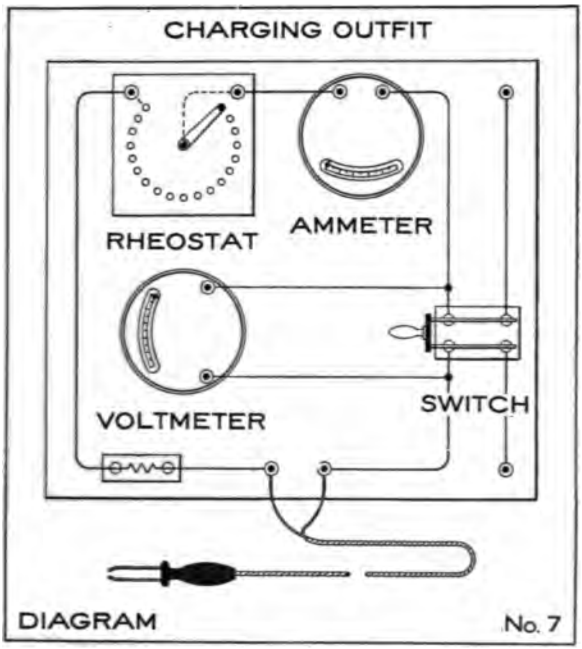
A 60-ampere-hour storage battery charged from a 110-volt light circuit at a rate of 15 amperes, would require 4 hours to charge and would consume in that time from the light circuit, 110 volts, multiplied by 15 amperes, or 1,650 watts per hour, which, multiplied by 4 hours, would be 6,600 watts, which, at 10 cents per thousand watts, would cost 66 cents. The cost per mile for operating an automobile would then simply be figured from the number of miles that a 60-ampere-hour storage battery would run the car.

A simple storage battery charging outfit is illustrated in Diagram No. 7. Before inserting the charging plug into its receptacle on the car, always be sure that the controller lever is in the off position. After attaching the charging plug to the car, throw the rheostat lever over to its starting point, so that all the resistance is in the circuit, then close the jack-knife switch and regulate the charging current by means of the rheostat, until the proper charging rate given by the battery makers is reached. The charging of the batteries should always be done according to the instructions given by the makers of the car or battery.

Storage Battery Troubles. The principal troubles to which a storage battery is subject are as follows:

SHORT-CIRCUITS. One form of trouble that may occasionally happen to a battery is short-

circuiting. It is sometimes caused by the active material scaling off and falling between the plates, or by sediment in the bottom of the cell. Should a foreign substance fall between the plates when the cell is open, that is sufficient in many



cases to cause trouble. Should trouble be suspected, it may be discovered by the marked difference in color of the plates or the specific gravity of the electrolyte, as compared with the other cells. No particular damage will be caused

if the trouble is discovered and removed at once.

Corrosion. Corrosion of the plates may occur from the chemical action due to the electrolyte decomposition of dilute acid in the pores of the active material, or the presence of lead-dissolving acids or their salts in the electrolyte.

The corrosive action of liquids on metals immersed in them takes place with the greatest rapidity at the surface of the liquid, and storage battery plates which project above the surface of the electrolyte deteriorate at its surface before the submerged portions of the plate have greatly depreciated. The plates should always be completely covered with electrolyte, and the lugs which pass from the plates out to the terminals made of thick, rolled lead.

Sulphating. The causes of sulphating are over-discharge or too rapid discharge, either of the entire active material of the plates or only certain portions of it, and the injurious effects are those which arise from great increase in resistance and excessive expansion.

Local action will cause sulphating, as will also short-circuits between the positive and negative elements of the cell.

As the sulphate is white in color, its presence is indicated by the gradual lightening in color of the sulphated parts of the plates.

Local Action. Internal discharge or local

action is another source of trouble. The remedy is to use pure electrolyte and keep the plates well covered. Local action often results in filling the pores of the active material with impurities and sulphate, thereby reducing the capacity of the cell.

Loss of electrolyte by evaporation should be made up by proper addition of dilute acid, about 5 per cent of acid to 95 per cent of distilled water. If the electrolyte does not completely cover the plates a smaller portion of the active material is exposed, and the cell capacity proportionally decreased.

Buckling of the Plates. Fracture and buckling of the plates is due to excessive or unequal expansion. It indicates that the discharge has been carried too far, the rate too rapid, or the current distribution over the plate not uniform, and that certain portions of the plates were too far or too rapidly discharged.

Loss of Active Material. Loss of the active material cannot be prevented if the active material is improperly formed or applied, and is of such composition that it disintegrates or loosens from the plate. Loss of the active material occurs, however, to a limited extent, due to too rapid expansion and contraction, which the plate cannot follow, or to the too rapid formation of gases when charging is done at a high rate, or the battery is over-charged.

EXCESSIVE DISCHARGE. Excessive or over-discharge tends to sulphate the exterior of the plates, which prevents the inner portion of the active material from participating in the discharge and causes the action to take place on the portion forming the outer layer, which results in over-discharge of the surface of the plate and the formation of a non-reducible sulphate.

LOSS OF VOLTAGE. This occurs frequently in a battery, one or more cells showing a lower voltage than the rest, and at times their polarity may even be reversed. This diminished voltage is due to surface sulphating of the active material in the plates, which must be removed.

Strength and Weight of Materials—See Materials—Table No. 17.

Structural Shapes. Table No. 23 gives the general dimensions, weight per foot and safe load for one foot of length, for angle, channel and tee sections of the minimum weight of each section rolled.

The safe loads given in the table are for a uniformly distributed load, on a beam, one foot in length between its points of support.

For a single center load the safe loads given in the table must be divided by two.

Example: What should be the safe uniformly distributed load for a $2 \times 2 \times \frac{3}{16}$ angle, the points of support being 5 feet apart?

Answer: Reference to the table shows that a

$2 \times 2 \times \frac{3}{16}$ angle, one foot long between its points of support, will carry a safe load of 1,330 pounds. Therefore 1,330 divided by 5, equals 266 pounds as the safe uniformly distributed load for the angle.

Example: What safe center load will a $2 \times \frac{3}{4}$ channel carry, the points of support being 7 feet apart?

Answer: The safe load given in the table is 2,800 pounds, this divided by 2 and by 7, gives 200 pounds as the safe center load.

Example: What size of tee iron will be necessary to carry a safe uniformly distributed load of 500 pounds, the points of support being 6 feet apart?

Answer: The safe load required, multiplied by the distance between the points of support, is equal to 500 multiplied by 6, which gives 3,000 pounds. Reference to the table shows that a $2\frac{1}{2} \times 2\frac{1}{2}$ tee will carry a safe load of 3,465 pounds.

The safe loads given in Table No. 23 are based on a maximum fiber stress of 60,000 pounds for steel, with a factor of safety of 6 to 1, giving a safe fiber stress of 10,000 pounds per square inch.

To ascertain the safe uniformly distributed load for a beam of any section given in the table, divide the safe load given by the length of the beam in feet.

Table No. 23.

Dimensions, Weight and Safe Loads of Structural Shapes.

Shape of section.	Section in inches.	Weight per foot in inches.	Safe load for one foot of length.
Angle	$1\frac{1}{4}$ x $1\frac{1}{4}$ x $\frac{1}{8}$	1.00	325
	$1\frac{1}{2}$ x $1\frac{1}{2}$ x $\frac{1}{8}$	1.20	510
	$1\frac{3}{4}$ x $1\frac{3}{4}$ x $\frac{3}{16}$	2.10	850
	2 x 2 x $\frac{3}{16}$	2.40	1,330
	$2\frac{1}{4}$ x $2\frac{1}{4}$ x $\frac{1}{4}$	3.60	2,130
	$2\frac{1}{2}$ x $2\frac{1}{2}$ x $\frac{1}{4}$	4.00	2,665
	3 x 3 x $\frac{1}{4}$	4.90	3,865
Channel	$1\frac{1}{2}$ x $\frac{1}{2}$	1.30	1,000
	$1\frac{3}{4}$ x $\frac{5}{8}$	1.45	1,330
	2 x $\frac{3}{4}$	2.60	2,800
	3 x $1\frac{7}{16}$	4.00	7,260
	4 x $1\frac{9}{16}$	5.25	12,660
	5 x $1\frac{3}{4}$	6.50	19,300
	6 x $1\frac{15}{16}$	8.00	28,860
Tee	$1\frac{1}{4}$ x $1\frac{1}{4}$	1.55	485
	$1\frac{1}{2}$ x $1\frac{1}{2}$	1.90	730
	$1\frac{3}{4}$ x $1\frac{3}{4}$	2.33	865
	2 x 2	3.50	1,665
	$2\frac{1}{4}$ x $2\frac{1}{4}$	4.12	2,200
	$2\frac{1}{2}$ x $2\frac{1}{2}$	5.40	3,465
	3 x 3	6.60	5,930

Substances, Weight per Cubic Foot of—See Table No. 24.

Supplies Necessary on a Car. The following supplies will be found very useful, especially on a long trip:

Asbestos.
Bolts and nuts.
Copper wire.
Emery cloth.
Emery powder.
Funnel.
Gasoline (extra can).
Gaskets.
Iron wire.
Machine screws.
Rope (small, strong).
Rubber pail.
Sticky tape.
Washers.

TABLE NO. 24.

WEIGHT PER CUBIC FOOT OF SUBSTANCES.

Materials.	Weight in Pounds.	Materials.	Weight in Pounds.
Ash, White	38	Mercury	849
Asphaltum	87	Mica	183
Brick—Pressed	150	Oak, White	50
Common	125	Petroleum	55
Cement—Louisville	50	Pine—White	25
Portland	90	Northern	34
Cherry	42	Southern	45
Chestnut	41	Platinum	1342
Clay, Potter's	110	Quartz	165
Coal—Anthracite	93	Resin	69
Bituminous	84	Salt	45
Coke	26	Sand—Dry	98
Earth	95	Wet	140
Ebony	76	Sandstone	151
Elm	35	Shale	162
Flint	162	Silver	655
Gold, Pure	1204	Slate	175
Hemlock	25	Spruce	25
Hickory	53	Sulphur	125
Ice	58.7	Sycamore	37
Ivory	114	Tar	62
Lignum Vitae	83	Peat	26
Magnesium	109	Walnut, Black	38
Mahogany	53	Water—Distilled	62⅓
Maple	49	Sea	64
Marble	168	Wax, Bees	60½

Swivel-joints—See Steering Connections.

Tachometer. A tachometer is an instrument for indicating the number of revolutions made by a machine in a unit of time—usually one minute.

Tanks, Capacity of Cylindrical. To ascertain the capacity in gallons of a cylindrical tank of given length, multiply the area of the cross-section of the tank in square inches by the length of

the tank in inches, and divide the product by 231, the result will be the capacity of the tank in gallons.

Tanks, Combination Radiator and Water—See Radiators.

Tanks, Gasoline and Water. Do not put the water in the gasoline tank by mistake, as many a new beginner has done. Always use a wire gauze-lined funnel. Although the drain of most tanks is usually a cock, the inlet is more often a screwed cap, this cap gets lost, and is often replaced by a cork. If this is done in the case of the gasoline tank the results from powdered cork getting into the carbureter and small pipes, is sure sometime to give rise to almost endless trouble.

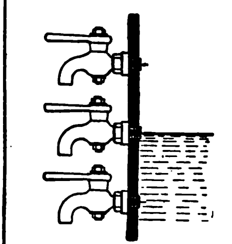


FIG. 92

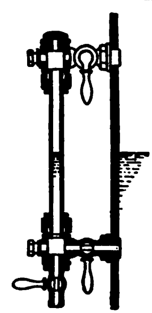


FIG. 93

Always fill or measure the contents of the tanks before starting. When filling the water tank after it has been emptied, do so with the drain-cock open for the first few minutes so as to force out any air bubbles which might get into the pump, or in a bend in the pipes, and put a stop to

the water circulation. This is known as an air-lock.

In case that there may be difficulty in ascertaining the level of the gasoline in the tank, gauge-cocks may be fitted in the side or end of the gasoline tank. Figure 92 shows a form of gauge-cock suitable for this purpose.

To determine the exact quantity of water in the tank, a gauge-glass as shown in Figure 93 is well suited, as the water level may be seen at a glance. In case of accidental breaking of the glass, the cocks at the top and bottom of the gauge may be closed.

Tap-drills—See Table No. 25.

TABLE NO. 25.

DIMENSIONS OF TAP-DRILLS FOR STANDARD V-THREADS, FROM 1/4 TO 1 1/4 INCHES.

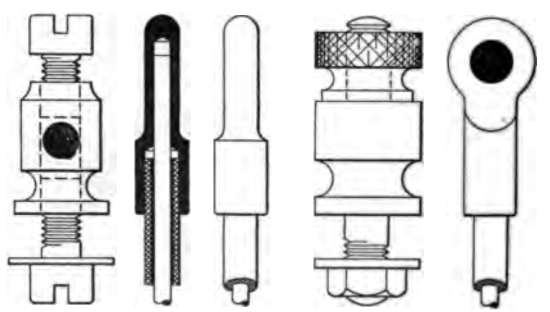
Diameter of Screw.	Number of threads per inch	Diameter at bottom of thread.	Nearest drill for full thread.	Correct size of tap drill.
1/4	20	.163	11/64	3/16
5/16	18	.216	7/32	1/4
3/8	16	.267	17/64	7/32
7/16	14	.314	5/16	23/64
1/2	12	.356	23/64	13/32
9/16	12	.418	27/64	31/64
5/8	11	.468	15/32	35/64
3/4	10	.577	37/64	43/64
7/8	9	.683	11/16	25/32
1	8	.784	25/32	29/32
1 1/8	7	.878	7/8	1 1/32
1 1/4	7	1.003	1	1 5/32

Tensile Strength of Materials—See Table No. 17.

Tee Iron—See Structural Shapes.

Terminals. With storage battery terminals, corrosion is inevitable unless the lead and brass parts are, when new, taken apart, and carefully painted with raw linseed oil or vaseline, and screwed up again. The entire binding-post may be drenched in linseed oil, it will not only prevent corrosion, but, strangely enough, improve the electrical contact between the wires and the faces of the terminals.

Two forms of terminals or binding-posts are shown in Figure 94. The one shown at the left



TERMINALS FIG. 94

in the drawing is more suitable for induction coil and dash-board connections. A tip or connector is also shown for use with this terminal, which

gives a far better electrical contact, than by the ordinary method of inserting the bared end of the insulated wire in the terminal itself. The bared end of the wire is sweated into the hole in the smaller portion of the connector as shown, the sheath or covering of the wire going into the hole in the larger end of the terminal. These tips are usually made of brass. The right-hand view shows a terminal or binding-post for storage battery use, which is heavier and larger than the one shown in the left-hand view. The connector for use with this terminal is also shown. The wire is attached in the same manner as for the other connector.

Testing Ignition Batteries. Get a 4 or 6-volt, one-ampere incandescent lamp, and after cutting the battery out of the charging circuit, put the lamp in the battery circuit for a few seconds only. If the battery is fully charged the lamp will give out a brilliant light. On no account use an ammeter to test a storage battery. It will injure the battery if kept in the circuit long enough to get an accurate reading.

Throttle Troubles—See Troubles, Throttle.

Throttle, Use of. A throttle is generally placed in the pipe between the carbureter and the admission-valve of the motor, to control the speed and power of the motor by reducing the supply of mixture. It is not by any means an efficient method of governing. The inefficiency of

the throttle is due to the fact that the efficiency of an explosive motor depends on the compression.

If the mixture be throttled so as to get a less volume, less compression pressure is the result, as with half the volume of mixture there is only half the compression pressure, therefore about half the efficiency. When running idle or very slowly, the saving of noise is worth the difference.

As it is important to keep up the compression pressure, and therefore the efficiency, throttling is therefore not an economical form of speed regulation—see also Motors, Speed Regulation of.

Tires. A single-tube tire differs from a double-tube tire in the fact that the inner or air-tube is vulcanized to the outer tube. In a double-tube tire they are separately attached to the rim of the wheel, and are not in contact except when the inner tube is inflated. A puncture through the tread of a single-tube tire may be repaired by the use of rivet-shaped rubber patches, which are inserted in the puncture and secured in place with cement. With a double-tube tire, the casing must be removed from the rim of the wheel, and suitably sized patches are then cemented upon the inner tube according to the nature of the puncture. When a puncture occurs on the road, the double-tube tire may be repaired in a similar manner to the single-tube, and when the tire is inflated, the air is retained by the inner tube and prevented

from leaking through the minute openings in the rubber and fabric of the casing.

Figure 95 shows cross-sections of single and double-tube automobile tires.

The lower view in Figure 96, shows a form of single-tube tire composed of a number of strands of thread running longitudinally on the tube and wound spirally with other threads which hold the longitudinal threads securely under inflation. The spiral windings are then pushed along the length of the tube, so as to reduce the distance between the windings from one-quarter of an inch to less than one-eighth of an inch, with the result that the intermediate sections of the longitudinal threads are pushed up into a series of loops, thus forming stronger attachments for the fabric, when held in the rubber wall built up over these layers of threads.

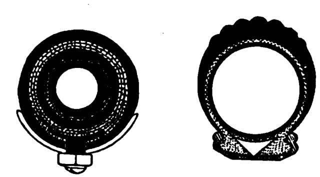


FIG. 95

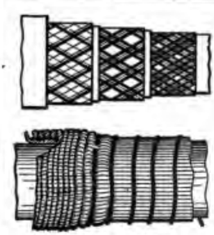


FIG. 96

The upper view in Figure 96, shows a method of strengthening the fabric of a tire against any

cause that would tend to burst or tear open the walls, and is a series of plies or layers of thread wound on in diagonally opposite directions, each layer being of a more open construction than the last, the closest winding being on the inner layer of the tire.

FIG. 97

A short section of an automobile tire with a tread having circular projections is shown in Figure 97. It is said to increase the tractive or adhesive properties of the tire, and also to reduce the danger of skidding or side-slip to a minimum.

Tire Repairs. A method of repairing a puncture in a single-tube tire by means of rivet-shaped plugs or patches is shown in Figures 98 and 99. Figure 98 shows the manner of making the repair and Figure 99 the placing of a strap or bandage of sticky tape around the tire and the rim of the wheel. The bandage is usually left on until it wears out.

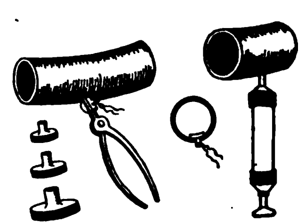


FIG. 98

The manner of removing the casing of a double-tube tire of the clincher type, to make a repair to the inner tube, is clearly shown in Figure 100.

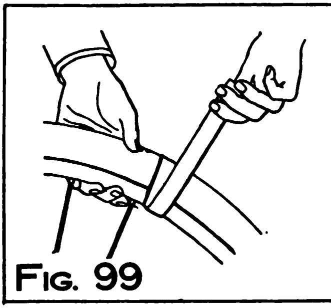


FIG. 99

Tonneau. The name or term used in connection with the rear seats of a motor car. Literally the word means a round tank or water barrel.

Tools Necessary on a Car. The following tools will not only be found useful, but in many cases absolutely necessary on a car:

Air pump.	Monkey wrench.
Cold chisel.	Oil can.
Densimeter.	Pliers.
Files.	Scissors.
Hammer.	Screw-driver.
Jack.	Spanners.
Key puller.	Tire removers.
Knife.	Tire repair kit.

Torsional Strength of Materials. The torsional strengths or resistance to distortion by twisting in pounds per square inch of different materials, are given as follows:

Bessemer Steel	80,000
Cast Iron	25,000
Cold Drawn Steel	80,000
Cold Rolled Steel	70,000
Machinery Steel	60,000
Tool Steel	100,000
Timber	1,200 to 1,500
Wrought Iron	45,000

Touring Car. A car with non-removable rear seats and a carrying capacity of 5 to 6 persons, with from 16 to 24 horsepower, is known as a touring car. Such a car generally has a running radius of 50 to 75 miles on one charge of gasoline and water—see Automobiles, Typical American, also Frontispiece.

Touring Sundries. Extra parts and supplies necessary for use when on an extended tour are as follows:

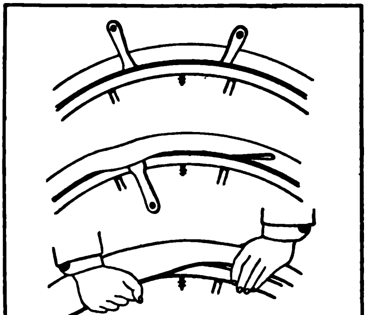


FIG. 100

Extra parts: Chain links, Batteries, Inner tubes, Insulated wire, Packing, Spark plugs, Valves, Valve springs.

Supplies: Acetylene (carbide of calcium), Cylinder oil, Goggles, Lap robe, Lamp oil, Lubricating oil, Storm apron, Tire bandage, Waste, Whiskey (for emergency use only).

Traction of Driving Wheels. A horse which exerts a pull of about 375 pounds continuously for an hour and goes a distance of one mile in an hour is working at the rate of one horsepower. If for any reason the horse is unable to exert as much as 375 pounds pull when going at the rate of one

mile per hour, he is thereby prevented from working at the rate of one horsepower.

The same rule applies to a motor car. When the road is not slippery there may occur a condition which does not appear with horse traction: that the tires fail to adhere to the ground owing to insufficient weight on the driving wheels. In such a case it is impossible for the motor-car to exert a push of 375 pounds without skidding the wheels, and thus it would be impossible for it to work at the rate of one horsepower. With underpowered motor-cars this difficulty does not occur, but to develop 10 horsepower at the rims of the driving wheels while covering the ground at the rate of one mile per hour, the car must exert a push on the road of 3,750 pounds. This is, on touring cars of ordinary weight, impossible, because the weight on the driving wheels is invariably less than 3,750 pounds, while the adhesion with the road is only a fraction of the weight on the rear wheels. As the speed rises, however, the push necessary for the development of 10 horsepower goes down until at 10 miles per hour a push of 375 pounds means 10 horsepower.

Thus a 40 horsepower car, if it could start work with the activity of forty horses, would, while it was moving at one mile per hour, exert no less a push than 40 x 375, which is equal to 15,700 pounds. This tremendous push is rendered impossible by the fact that the wheels of a car

weighing 2,000 pounds only grip the ground enough to exert about 750 pounds push. Beyond this point they will skid.

This shows that a high-powered car, when the car is moving slowly, cannot develop its full power unless the road wheels are capable of adhering to the ground sufficiently to transmit this power. As a rule only about 0.6 of the weight of the car is on the driving wheels, and of that only 0.625 is available for the adhesion (owing to the coefficient of friction between rubber and road being 0.625). So a 10 horsepower car weighing 2,000 pounds cannot exert its full power when the car is starting, nor until it is traveling at 5 miles per hour.

It would be wrong to contend that on all cars having the weight distributed as at present, a 60 horsepower motor is useless, but it is needless to say that the output of such a motor is not available at starting or at any speed under 30 miles per hour, although the whole power is more needed then than at any other time. The remedy which suggests itself is by using all the adhesion of the car, that is, to drive with all four wheels.

Transmission of Power, Efficiency of. The efficiency of various forms of drives between the motor and the driving wheels of a motor car may be estimated as follows:

Single-chain, with direct drive on the high speed, between the motor and rear axle—85 per cent.

Two-chain drive, from motor to speed-change gear, from speed-change gear to rear axle—75 per cent.

Quarter-turn or right-angle drive, with double-chain drive to free rear wheels—70 per cent.

Longitudinal shaft drive, with universal joints and bevel gear in differential case—65 per cent.

Trembler—See Electrical Ignition, also Vibrator Coil.

Troubles—See Battery, Carbureter, Clutch, Road and Starting Troubles.

Troubles with Batteries and Ignition. The reason for the troubles experienced with batteries and ignition devices on gasoline automobile motors is from the high speed at which such motors are run and the greater amount of heat developed, as compared with stationary or marine gasoline motors.

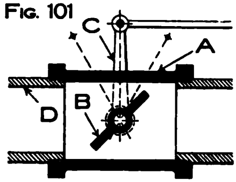
Troubles, Throttle. Slowing down the speed of a motor by throttling the charge, should not be resorted to, until the ignition has been retarded as far as possible. If the motor speed be reduced, by first throttling and then afterwards retarding the ignition, or by a combination of the two, it generally results in misfiring of the motor.

A butterfly-valve or form of throttle commonly used is shown in Figure 101. The valve-chamber *A* has the valve *B* operated by the lever *C*. The valve is located at any suitable point in the

admission-pipe *D* between the carbureter and the admission-valve of the motor.

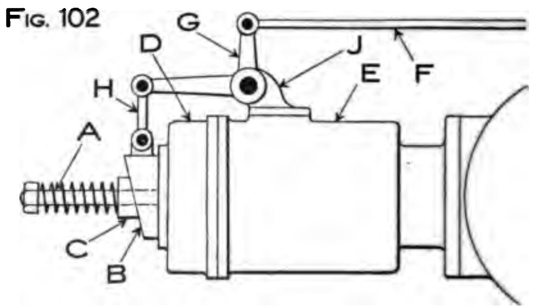
A form of admission-valve governor or throttle is shown in Figure 102. The pressure of the spring on the admission-valve stem *A* is increased or decreased by means of the wedge *B*, acting on the taper washer or collar *C*. The valve is located in the cylinder-head or combustion chamber *D* of the cylinder *E*, and is operated by means of the rod *F*, through the bell-crank lever *G* and link *H*. The bell-crank lever is carried by a bracket *J*, on the top of the cylinder as shown.

FIG. 101



THROTTLE

FIG. 102

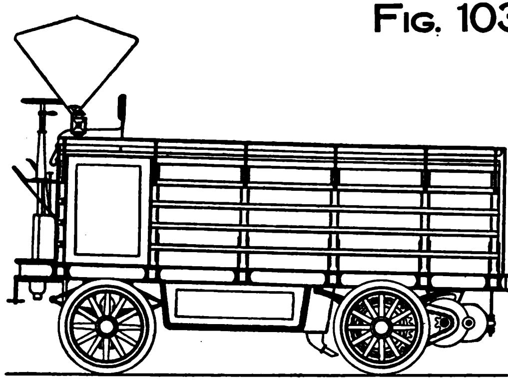


ADMISSION THROTTLE

Truck, Heavy. For heavy freighting and depot work in large cities, electric trucks or wagons

seem to predominate, on account of their simplicity, freedom from vibration and absence of noise or odor. The truck illustrated in Figure 103 has a carrying capacity of 8,000 pounds, with

FIG. 103



speed of 6 to 8 miles per hour, and a running radius of 25 to 30 miles on one battery charge.

Tube-ignition—See Ignition, Hot Tube.

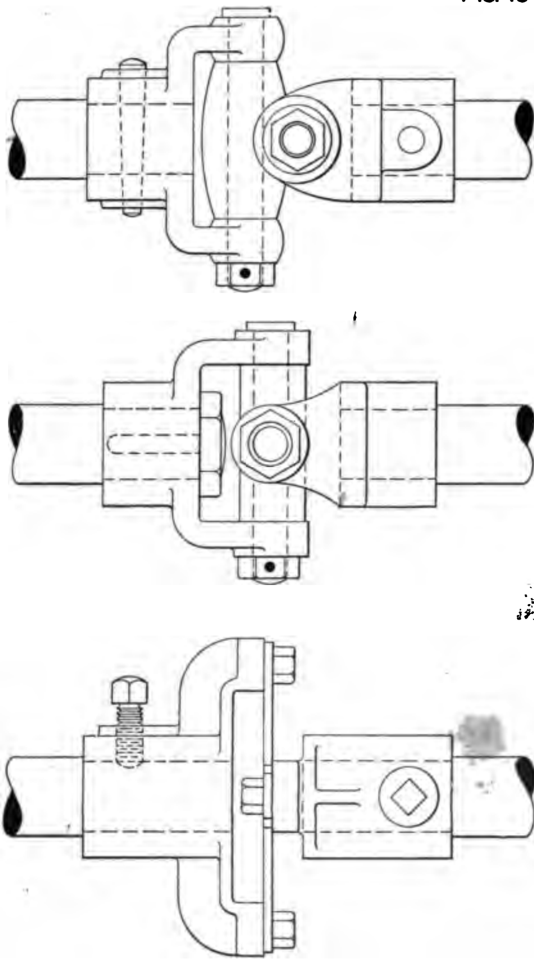
Two-cycle Motor—See Motor, Two-cycle.

Universal-joints. The elementary form of a universal-joint or flexible coupling consists of a spiral spring. Such a form of universal-joint is sometimes used to drive a rotary pump or a small generator on a car. The rear wheels or axle of a car are sometimes driven by means of a longi-

tudinal shaft with a quarter-turn drive on a counter shaft or a bevel gear drive attached to the differential gear of the rear axle. In such cases some form of universal-joints is necessary to allow the rear wheels and axle to accommodate themselves to the inequalities of the road surface. Three forms of universal-joints are shown in Figure 104. The upper view in the drawings shows the form most generally used on motor-cars, for the purposes just described. The one shown in the center view will allow a greater amount of angular distortion than the form shown in the upper view, but is of a more expensive construction. Where only a slight amount of angular distortion is needed, the construction shown in the lower figure in the drawing is very suitable, the two jaws or knuckles of the joint being flexibly attached by means of a plate of spring steel in the form of a cross.

Valves. A valve in a very bad or pitted condition causes bad compression and the exhaust-valve should be ground occasionally. After grinding the exhaust-valve be sure that there is ample clearance between the valve and the lifter. It should have not less than one-thirty-second of an inch, otherwise when the valve becomes hot it will not seat properly, poor compression being the result. In grinding a valve there is no occasion to use force, and the grinding should be done lightly, the valve being lifted from

Fig. 104



UNIVERSAL JOINTS

time to time so that any foreign substance in th emery will not cut a ridge in the seat or the valv itself. After grinding the valve always wash ou the valve seat with a little kerosene and be carefu that none of the emery is allowed to get into th motor cylinder.

METHOD OF GRINDING. Valves which nee reseating should first be ground in place with fin emery and oil, then finished with tripoli an water.

EXHAUST-VALVE STICKING. Sometimes a mo tor may suddenly stop from the failure of th exhaust-valve to seat properly. This may be du to the warping of the valve through the moto having run dry and become hot, or it may be fron the failure of the valve spring or the sticking of th valve-stem in its guides. The valve should b removed, and the stem cleaned and scraped, o straightened if it requires it, until it moves freel in the guide, and the spring is given its full tension If the valve still leaks so that the motor will no start or develop sufficient power, the valve wil have to be ground into its seat.

AUXILIARY AIR-VALVE. It has been deter mined from the result of experiments that to ge the maximum power at any speed from a gasolin motor equipped with a float-feed carbureter, th jet of the carbureter must have a larger openin for low speeds than for high speeds. As this prac tice would require a very delicate adjustment i

consequently becomes almost impracticable, because necessitating a constantly varying regulation for each fractional variation of speed of the motor. The difficulty may be obviated by the use of an auxiliary air-valve, located in the induction-pipe close to the inlet-valve of the motor.

The jet of the carbureter is set for the maximum quantity of gasoline at the slowest speed of the motor, and as the speed is increased the auxiliary air-valve comes into action and reduces the supply of air passing through the carbureter, thereby reducing the suction or partial vacuum at this point, and maintaining a constant quality of mixture at all times.

Valve-stems, Weak Points of. Recent experiences call attention to the fact that a change is necessary in the construction of valves, or rather that part of the valve attachments adopted, by some designers, to hold the spring in position. This remark applies particularly to the vertical type of valve, but the same defect has been found in horizontal valves. Opinions vary as to the best method of securing the springs in position, some designers preferring pins, either round or square, others the nut and cotter. Both have points in their favor and some common faults. It is doubtful, however, whether the method of slotting or broaching the stem and then using a key for securing the spring, is as secure as that of using a

nut and pinning it to prevent its becoming loose. Under the latter plan there is no drilling of the stem except for a small cotter or split-pin and the nut carries the strains, whereas in the other method the strain bears on the stem at the point at which the slot is made for the key, the latter being the means by which the strain is carried to the stem. Especially is the slotting of the stem unsafe when the stem is hardened, for vibration plays havoc with the valve. Many breakages have occurred from this cause and the question has become serious. While it is a fact that both kinds have suffered, the nut method of fastening is to be preferred, from the fact that even though the split pin may break and drop out, and the nut become loose, the trouble can be temporarily remedied by an extra piece of wire, while the slotted stem breaks off at a point where the metal is thinnest and makes the valve useless.

TIMING THE VALVES. The movement of the valves should always be timed to give the proper results. This is an important point to remember. The exhaust-valve cam shaft on a four-cycle motor is usually driven by the two to one gear on the crank shaft, and if for any reason the gears are taken apart and put together, even if only one tooth is out of place, it will throw the valve and spark mechanism out of time.

To ascertain if the exhaust-valve of a motor is properly timed, turn the flywheel over slowly and

notice at what points the exhaust-valve opens and closes, and when the ignition takes place.

The exhaust-valve should open slightly before the beginning of the inward stroke and close at the end of the same stroke. The next inward stroke is the compression stroke, when both valves should be closed.

NEEDLE-VALVES. Valves with cone-points and having a fine thread on the stem are known as needle-valves and are used for the regulation of the supply of gasoline to the carbureter or mixing valve of a motor—see Carbureters.

BUTTERFLY-VALVES. This form of valve is generally used in the admission-pipe between the carbureter and the admission-valve of the motor, to regulate or throttle the supply of explosive mixture to the motor—see Throttle.

SWING CHECK-VALVE. Valves with a hinged disk, usually set at angle of 45 degrees, are sometimes attached to the air-inlet opening of the carbureter to prevent leakage of the mixture, when atmospheric or suction operated admission-valves are used.

GLOBE VALVES. This form of valve is usually placed in the outlet pipe of the gasoline tank, to shut off the gasoline from the carbureter.

Variable-speed Devices—See Friction Drives, also Power Transmission Devices.

Vibrator—See Electrical Ignition, also Induction and Vibrator Coils.

Vibrator Coil, Current Used with. A properly designed vibrator coil will not use as much current as a plain jump-spark coil. The self-induction in the primary circuit caused by the high frequency of the pulsations tends to check the flow of the current to a far greater extent in a vibrator coil than in a plain jump-spark coil. The amount of the retardation of the current in the primary winding of a vibrator coil can be calculated to a nicety, when the number of pulsations of the coil per second are known, but this calculation involves the use of logarithms and a knowledge of higher mathematics.

Vibrator, Independent—See Electro-magnetic Vibrator.

Voltmeter—See Ammeter.

Voltmeter, Use of—See Battery Troubles, also Storage Batteries.

Vulcanized Fiber—See Fiber.

Washers—See Insulating Material.

Water Circulation. There are two systems of water circulation in use for cooling the cylinders of explosive motors: The natural or thermal-syphon system and the forced water circulation.

In natural or thermal-syphon water circulation the fact that cold water is heavier than hot water is taken advantage of. A head of water is obtained by placing the tank above the level of the cylinder water-jacket, and as the water in the

jacket is heated by the combustion, the cooler water from the tank flows in, forcing the heated water in the tank to take its place, and in this manner an automatic circulation of water is set up. The pipes must be so arranged that they offer every facility for the free circulation of the water, the cold water leaving through a pipe at the bottom of the tank and entering at the lowest point of the cylinder, while the hot water leaves the top of the cylinder and enters the tank at the side near the top. The water circulation, though automatic, is very slow, and for this reason requires a larger body of water to produce as good a cooling effect as a forced circulation.

In forced circulation a rotary pump is used, the direction of the flow being such that the water passes from the pump to the cylinder, thence to the radiator, on to the tank, and then through the pump again, thus completing its circuit. The water in this way gets the maximum cooling effect from the radiator, and the body of water in the tank is kept cool. On account of the high speed of a gasoline automobile motor, and the comparatively small amount of power required to circulate the water, rotary pumps are much used. As there are no valves to get out of order, and high speed is obtainable, this type of pump is very suitable for automobile use.

The upper and lower views in Diagram No. 8 show the principles of operation of the gravity or

thermal-syphon, and the forced or pump circulating systems, respectively.

Water-jackets. The thickness of the water-jacket space around the cylinder of an explosive

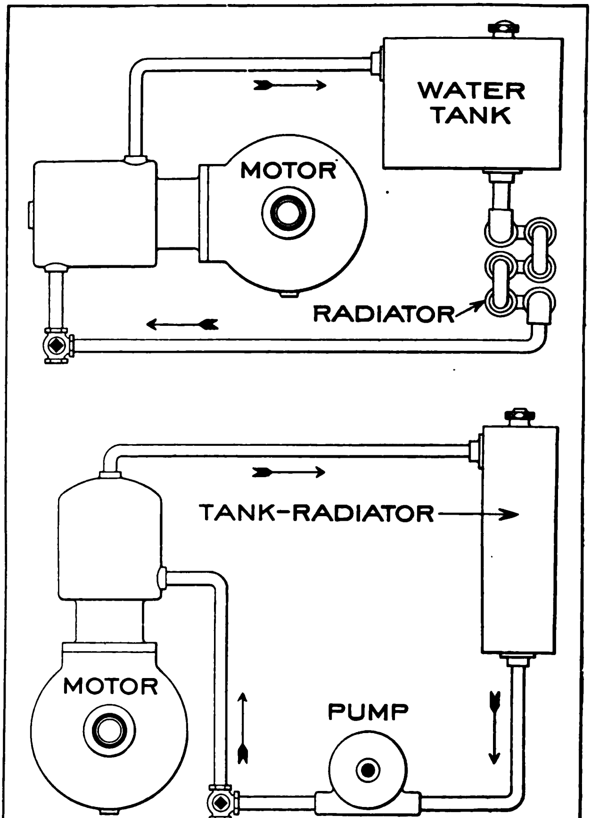


DIAGRAM No. 8

motor should not be less than one-eighth of the bore of the cylinder, while the water space surrounding the head combustion chamber of the cylinder should not be less than one-sixth of the cylinder bore.

Bosses for pipe connections to the water jacket outlet should always be placed at the highest point of the jacket, so as to prevent an air space being formed above the outlet of the jacket. Steam will be formed in this space, and with a gravity or thermal-syphon system is liable to blow or force the water out of the cylinder jacket.

To obtain the greatest degree of fuel economy and motor efficiency the jacket water should be always of a temperature slightly under the boiling point of water. A cool water-jacket is a sign of an inefficient motor.

Water-jacket, Leaks in. A leak in the water-jacket of the cylinder of a gasoline motor may be due to one of two causes: Either to spongy places in the metal of the jacket from imperfect foundry work, or to cracks in the jacket from allowing the water to stay in the cylinder jacket during extremely cold weather and the car not in use. The spongy place or crack may be repaired by using one of the two following solutions: Remove the cylinder from the motor and first wash out the inside of the jacket with a 20 per cent solution of sulphuric acid and water, taking care, however, not to let any of the solu-

tion get on any of the finished parts of the cylinder. For a spongy place in the jacket use a saturated solution of sal-ammoniac and place the cylinder in such a position that the spongy place is underneath; allow to stand in this position for at least two or three days. Then empty out the solution and leave the cylinder standing for two or three days more, until the leak has thoroughly rusted. For a cracked water-jacket, keep the water-jacket full of a saturated solution of sulphate of copper (blue vitriol) for at least four days. The crack is filled up by what is practically an electro-chemical deposit of pure metallic copper.

Water-tanks—See Leakage, also Tanks, Capacity of, and Tanks, Gasoline and Water.

Watt-hour, Definition of. A current of one ampere flowing in a closed electric circuit, with an electro-motive force of one volt, is equal to one volt-ampere or one watt. The voltage of a circuit, multiplied by the rate of the current flowing in amperes, gives the rate of work, or energy expended in watt-hours.

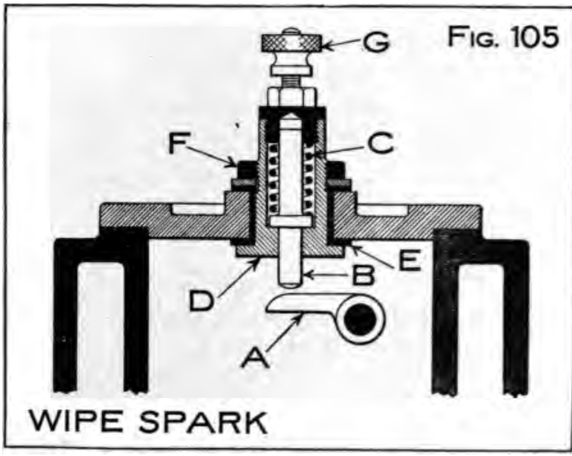
Weight of Substances — See Substances, Weight of—Table No. 24.

Wheels, Driving—See Driving Wheels, Large versus Small.

Wheels, Speed of—See Speed of Wheels.

Wheel-steering Devices—See Steering Devices.

Wipe Spark. A form of primary sparking device which is in use on some gasoline motor-cars, but principally used on marine and stationary gasoline motors. A form of wipe or touch spark is illustrated in Figure 105, in which the make and break is between a rocker arm located



A—Rocker contact arm. *B*—Spring-actuated plunger.
C—Coil spring. *D*—Insulated bushing.
E—Mica insulation. *F*—Lock nut.
G—Terminal nut.

in the side of the combustion chamber and a spring plunger immediately above the end of the arm, and in the center of the cylinder head. The reference table given above in connection with the drawing will explain the construction clearly.

Wire, Copper—See Carrying Capacity of Bare and Insulated Copper Wire—Table No. 26.

Wire Gauge—See Table No. 26.

Wire, Platinum—See Platinum.

Wire, Primary—See Ignition Circuits, als Wiring for Ignition Circuits.

Wire, Secondary—See Ignition Circuits, als Wiring for Ignition Circuits.

TABLE NO. 26.

RESISTANCE AND CARRYING CAPACITY OF BARE AND INSULATED COPPER WIRE.

B. & S. Gauge.	Diameter in inches.	Ohms per thousand feet.	Carrying Capacity in Amperes.	
			Insulated.	Bare.
6	.162	0.411	65	65
7	.144	0.519	56	56
8	.128	0.654	46	46
9	.114	0.824	39	39.2
10	.101	1.040	32	32.5
11	.091	1.311	27	27.8
12	.081	1.653	23	24
13	.072	2.084	19	19.6
14	.064	2.628	16	16.3
15	.057	3.314	10	13.9
16	.051	4.179	8	12.0
17	.045	5.269	6	9.8
18	.040	6.645	5	8.1
19	.035	8.617		7.0
20	.032	10.566		6.0

Wiring for Ignition Circuits. Multi-cylind gasoline motors may have the wiring of the ignition circuits arranged in various manners, a follows:

TWO-CYLINDER MOTOR. Single-coil, with th two spark plugs in series with each other. A fou terminal coil is necessary to use with this arrang ment.